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Bargaining Solutions to Externalities.

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BARGAINING SOLUTIONS
TO EXTERNALITIES

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
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in

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by

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ABSTRACT

This dissertation addresses the relationship between the Pigovian and Coasian schools of externality policy. By varying the definition of the aggregate externality constraint, the results of Pigou as well as those of Coase are obtained. The Pigovian problem is one of public reception of pollution; the Coasian problem is one of locational confinement of pollution. The model shows that private internalization will achieve efficiency in the Coasian case where bargaining is possible regardless of the liability rule. Moreover, if bargaining is prohibited in the Coasian case (i.e., the large number problem), the efficient tax policy differs from the standard Pigovian unilateral tax.

INTRODUCTION

Since the "externality revolution" of the 1960's two theoretical approaches have been accepted as offering efficient solutions to spillover problems. In terms of historical development the work of A. C. Pigou comes first. The Pigovian tradition is well summarized by Fisher and Peterson. (76, page 12)

Suppose a firm's production generates . . . an externality that directly affects other economic agents. Then the marginal social cost of production will diverge from the marginal private cost, and the firm will produce "too much" pollution. The implied policy is to levy a tax equal to the difference between marginal social and marginal private costs.

Much later, as externalities became a household word in the profession, an analysis by R. H. Coase began to have a major impact on the theoretical discussion. His results have come to be known as the Coase Theorem. The theorem holds that when the actions of one firm affect another, for competitive industries and in the absence of transactions costs, the firms will be forced by their own maximizing behavior to bargain to a solution that is socially efficient. While both Pigou and Coase seem to describe a similar problem their solutions differ. Is it that the

problems differ, or is one of the solutions theoretically incorrect?

It has been suggested by many writers, notably Buchanan (73), that the problems differ simply in terms of the number of affected parties. If there is a large number of affected parties, Pigovian policy is called for;¹ if there is a small number, the Coase Theorem holds. However, this dichotomy does not resolve the conflict completely. The question of "Who should pay?" still confounds the correctness of both the Pigovian tax and the Coase Theorem.

Baumol, in assessing Coase's attack on the Pigovian tradition, says that even in the large number case Coase's arguments pose the following question: "Should not a tax sometimes be levied, at least in part on those who choose to live near the factory rather than upon the factory owners?" (72, Page 309) Baumol answers this question negatively and reaffirms the single Pigovian tax. However, Meade (52) and Gould (73) show Pigovian taxing models where the damaged party should be compensated. Also, Tybout (72), Schulze and d'Arge (74), Shapiro (74), and more recently Hansmann (77) all argue that the Coase solution fails to achieve optimality under alternative definitions of property rights (payment flows).

¹Although Coase and Buchanan may not agree with Pigovian policy in any case, when the number of externality affected parties is large, they offer no alternative.

The basic controversy continues. Under what circumstances are Pigovian taxes, as opposed to private internalization, necessary to achieve efficiency? If private internalization fails, what is the appropriate structure of the tax? If private negotiation is possible, will the parties correctly internalize the spillover? The major objective of this research is to suggest and to attempt to clarify some of the answers to these three questions. A model is developed that allows for either the Pigovian or Coasian assumptions. The Pareto welfare conditions are derived and examined in each case. Finally, the policy implications are discussed.

The findings of this research suggest two important analytical points. First, a more elaborate taxonomy of externalities than that offered by Buchanan is required. The taxonomy offered by this research incorporates the notion of public versus private externality reception, as presented by Meade (52) and Gould (73), into the classification scheme based on the number of externality affected parties.² This more elaborate classification allows for alternative representations of the aggregate externality

²Although the definitions are pursued extensively in Chapter II we can state here that public externality reception occurs when the amount received by one firm does not diminish the amount available to others. A private externality exists when the reception by one firm does limit the reception by others.

effects. It is then shown under what circumstances Pigovian policies are appropriate and where only Coasian prescriptions yield efficiency.

The second analytical contribution offered by this research is the importance of the notion that some externalities are spatially bounded. The locational restriction imposed by this bounding limits the number of firms. The explicit recognition of locations confinement of spillovers allows the Coase Theorem to be viewed as an adaptation of the efficiency properties of rents on land. It also forms a distinction between Coasian and Pigovian cases.

The models developed in this research draw on these two contributions: the extended taxonomy and the explicit treatment of locational confinement of externalities. The conclusions of the research are: 1) The Coase Theorem is applicable in certain cases, some of which have not been previously demonstrated. The Coase Theorem suggests optimal taxing models that are not part of the Pigovian tradition; 2) The unilateral Pigovian tax may be of only limited importance because few problems satisfy the conditions that call for its application; 3) The bilateral tax/subsidy scheme of Meade and Gould is efficient in certain cases that may be more common than those calling for the simple Pigovian tax.

The analysis yielding these results begins in Chapter I with a review of the literature. A historical outline

of the existing literature is used. Although the main goal of the literature review is to outline the background for the classification scheme used herein, it should also indicate to the reader the breadth of the rift between the two schools. Historically, the Coase Theorem has clashed with the Pigovian tradition of unilateral taxes or subsidies.³ Baumol (72) opens his article with the statement, "It is ironic that just at the moment when the Pigovian tradition has some hope of acceptance in application it should find itself under a cloud in the theoretical literature." (page 307)

Chapter II presents the alternative taxonomy drawn from the literature cited in Chapter I. Chapter III develops the Pareto welfare model used to identify the optimality conditions for the various types of externality problems. The optimality conditions are derived and interpreted. Chapter IV elaborates on the development of the Pareto conditions of Chapter III for the Coasian cases. The importance of locational restriction for the Coasian cases is discussed. Chapter V demonstrates the validity of the Coase Theorem under zero transactions costs and locational confinement of the externality.

Finally, Chapter VI discusses the findings in terms of the reconciliation of the Pigou-Coase controversy. The

³ See, especially, Buchanan and Stubblebine (62).

claims of Coase and Pigou are set forth, and a qualitative discussion of the importance of each is undertaken. The goals of this research are to reconcile the Pigovian and Coasian traditions, to indicate the variations in the appropriate tax prescriptions, to demonstrate the correctness of the Coase Theorem and to develop its place in a general outline of externality problems. A discussion of the relevance of the Coase Theorem is, then, the major focus of Chapter VI.

CHAPTER I

A REVIEW OF THE PERTINENT LITERATURE

Introduction

This research is initiated by the fact that there is apparently an unresolved conflict between the Pigovian and Coasian schools of externality theory. This conflict is evidenced by the arguments against the Pigovian tax made by proponents of the Coase Theorem, by disagreements among Pigovian supporters concerning the form of the tax, and by propositions that efficiency does not obtain in the Coasian case due to the effect of competitive entry and exit of firms. The purpose of this dissertation is to offer a reconciliation of the competing traditions. The purpose of this chapter is to identify the inconsistencies in the theory.

Specifically, the goals of this research are threefold:

- 1) develop an outline of externality problems which include both Pigovian and Coasian definitions;
- 2) examine the type of government policy necessary where private internalization

is impossible; 3) demonstrate the efficiency properties of private internalization where it is possible.

This paper divides externalities into four categories based on the distinctions between large or small numbers of involved firms and public or private externality reception. This distinction is important in achieving the first goal of the study, i.e., developing a complete outline of externality problems. Although the threads of such distinctions exist in the current literature, as discussed below, the externality literature has not made such distinctions in a rigorous fashion.

After discussing the debate between the followers of Pigou versus those of Coase, the recent literature on the Coase Theorem itself is reviewed. Special interest is placed on the industry adjustment discussions of the contributors.

Before beginning the review of the literature a formal definition of externality is necessary to guide and limit the research.

A technological externality exists when the actions of one firm enter the production function of other firms and there is no explicit market regulating these effects. Hence, the two modes for internalization of the spillover are either government intervention or private bargaining

among the individual parties.

Consider the following general form of a firm's production function.

$$f^i(q_i, x_i, y_i, y_j) = 0 \quad i \neq j$$

Here the term " q_i " is the output produced by the i^{th} firm; " x_i " is its input; " y_i " is the variable measuring the spill-over produced by the i^{th} firm; and " y_j " is the externality received by firm i from firm j . The function $f^i(.)$ specifies the relationship between these variables for the i^{th} firm. This form may be simply expanded by considering the variables within $f^i(.)$ as vectors instead of single values. Firm i is said to be the "producer" of an externality when $y_i > 0$, and a "receiver" when $y_j > 0$. The term polluter refers to the case where $y_i > 0$, and $\partial f^j / \partial y_i < 0$, $j \neq i$. In other words, firm i at the margin negatively affects firm j 's production.

Review of the Literature: Pigou versus Coase

A. C. Pigou is hailed as the first economist to define externalities and to attempt to remedy the social welfare loss arising from externalities. While the problem and many of the answers actually predate Pigou,⁴ he offers an explicit

⁴See Johnson (73) who shows that as early as 1883, Henry Sidgwick had a firm grasp of the problems of public goods, the free rider, and potential problems with government solutions.

tax/subsidy scheme as a solution to the problem of the technological externality. Pigou's welfare criterion is that the national dividend will be maximized if the marginal social net products are equal. If externalities exist, the marginal social net products deviate from the private ones and welfare falls short of the maximum. When this occurs, Pigou claims it may be possible to achieve this maximum by a set of taxes or subsidies that bring private and social products into equality. Pigou was uncertain of the computational details of this tax/subsidy, but he was convinced that such values existed and were determinant.

Although Pigou's position was initially attacked by some,⁵ it gained professional acceptance and was further developed. Meade (52) developed a specification of the magnitude of the appropriate Pigovian tax/subsidy for the special class of linearly homogeneous production functions. At the same time Meade argued that in some cases both taxes and subsidies are necessary to maximize social welfare. This was the first mention of bilateral intervention

⁵ Most notable was Knight's work (24). Knight cites other writers who held his opinion of Pigou's work.

outside of reciprocal effects,⁶ and it is the beginning of the public versus private externality distinction developed in this paper.

The continued recognition of the Pigovian tax/subsidy scheme is evidenced by the treatment accorded it in such traditional price theory texts as Henderson and Quandt (58, revised 71). Notably, the Henderson and Quandt treatment is in terms of the Pareto welfare concept and they say that the efficiency conditions can be deduced from the actions of joint profit maximizing firms. Those sectors of the economy characterized by externalities could be thought of as two firms. Pareto optimality, then, requires the joint profits of the two firms to be maximized. Stated another way, the Pareto requirements are that the price of good one should equal the marginal costs of the production of good one plus the marginal cost (or less the marginal benefit) imposed on the production of good two. Henderson and Quandt say: "The quantities (of the two goods) that would be produced under joint profit maximization can be

⁶ The term reciprocal refers to the case where one economic agent's activities affect another in the externality sense, and at the same time the second party also does something to affect the first. This is the case of a bilateral externality which, for simplicity's sake and with no loss of generality, we can treat as separate cases. However, Meade is referring to a bilateral tax/subsidy in the case of a unilateral externality. This is clearly different from the standard Pigovian analysis.

enforced by appropriately taxing and subsidizing producers if they maximize profits individually." (58, page 217)⁷

Coase's work (60) was the first major attack on the Pigovian position to become accepted by the profession. Coase claims that the private market can handle many of the divergencies between social and private costs envisioned by the writers of the Pigovian tradition. Coase devotes considerable space to considering types of externalities proposed by Pigou and others where a voluntary solution certainly could have, or had been worked out.

His position against the Pigovian tradition is that the mere existence of technological externalities is not sufficient to show the necessity for Pigovian taxes/subsidies. In most if not all cases, the externalities will be internalized by the independent actions of the participants. Coase wondered why, when one observes spillover effects in the real world, it is automatically assumed because of their simple existence they are at nonoptimal levels.⁸ The acceptance of the Pigovian taxing strictures seems to be based on such a blind assumption.

⁷The "if" in this statement certainly implies something like the Coase Theorem. Furthermore, most of the more recent work on bargaining has done little more than reiterate this analysis.

⁸This is especially ironic since the Pigovian solution may yield a situation where there is a non-zero level of pollution.

One of Coase's most famous examples is the case of the candy manufacturer and the doctor.⁹ A doctor set up residence next to a confectioner who operated two machines in the pursuit of his trade. Things proceeded perfectly well for some years until the doctor added a consulting room next to the kitchen housing the machines. Because of the noise of the machines, the doctor was prevented from ". . . examining his patients by auscultation for diseases of the chest . . . (and finding it) impossible to engage with effect in any occupation which required thought and attention.'" He brought suit and won an injunction barring the operation of the machines, which the confectioner had been running for 60 and 26 years respectively. Coase's conclusion is that:

The court's decision established that the doctor had the right to prevent the confectioner from using his machinery. But, of course, it would have been possible to modify the arrangement envisaged in the legal ruling by means of a bargain between the parties. . . . The solution of the problem depends essentially on whether the continued use of the machinery adds more to the confectioner's income than it subtracts from the doctor's.

More explicitly, the court's ruling did nothing more than define a property right that could then be sold to the highest bidder. Coase continues to explain that had the doctor lost, the result would have been the same except that the

⁹Coase (60), page 729.

payment flow would have gone in the opposite direction. Coase argues that the income effects are included in the same magnitude in both parties' profit function regardless of the direction of flow of the payment. Nothing is changed if the property right is reversed, because an opportunity cost is the same as a direct cost.¹⁰

Closely following Coase's article was one by Buchanan and Stubblebine (62). This article is a more rigorous statement of the Coase Theorem. They demonstrate, among other things, that a Pigovian tax would not only be unnecessary but would lead to inefficient solutions in many cases of externalities. Specifically, they show that in externality cases where individual bargaining among participants is possible (i.e., small number cases) the Pigovian tax is inappropriate. This point forms the basis for the small versus large numbers issue. They choose to state their case in utility maximization terms thereby avoiding the

¹⁰ Coase argues this by saying the party receiving the payment will treat the payment as an opportunity cost. For the party making the payment it is a direct cost. Note that this payment forms the basis of the more recent work on bargaining models of externalities. Also note that in terms of the wealth effects for consumers, Dolbear (67) points out that changes in wealth due to changes in the externality property right, will change the optimal solution quantities of the affected parties.

wealth distribution problem that might affect firms in long run industry equilibria.¹¹

Buchanan and Stubblebine define various states of exchange between two individuals interlocked in an externality. Of importance is the fact that at the Pareto equilibrium, the externality still has a marginal effect. The imposition of a Pigovian tax to reach Pareto optimality will have the result that the negatively affected party will bid the solution past Pareto optimality toward too little pollution.

¹¹Buchanan and Stubblebine lucidly handle the question of the usage of the tax revenues that result from the government intervention. Shibata (72) argues against the Buchanan and Stubblebine treatment of the tax revenues and the possible Pareto repercussions that might result. Specifically, Shibata tries to demonstrate that it is not the tax which Buchanan and Stubblebine claim will lead to inefficiency but the use of the revenues of the tax. The Buchanan and Stubblebine (72) reply to Shibata's criticisms is well taken and forms the gist of the position we take concerning the tax problem. The Pareto conditions derived in the following chapters are sets of relationships that show the interactions between not only the production sectors of the economy but also the consumption sector. The first order Pareto conditions must be met to achieve optimality. But, as is well known, there are an infinity of options from which to choose. Any complete fiscal policy must definitionally include some implicit or explicit definition or redefinition of property rights. Thus, for instance, if all the optimal tax revenues are given consumer j , he will reallocate his consumption pattern in line with a changed income flow. This in turn may affect the demand and supply curves for goods and the resources respectively, but at the equilibrium point, the tax having been recomputed to account for these changes in demand and supply, the relative prices between the goods in the economy will have to embody the stated Pareto conditions for efficiency to exist.

The Buchanan and Stubblebine position can best be summed up by the following quote:

The important implication to be drawn is that full Pareto equilibrium can never be attained via the imposition of unilaterally imposed taxes and subsidies until all marginal externalities are eliminated. (page 383)

While they do not state it explicitly, the implication is clear that the Pigovian policy is never applicable unless it is unnecessary. If marginal externalities are eliminated, the Pareto optimum is attained.

Extending the analysis of Buchanan and Stubblebine, Turvey (63) and Wellisz (64) show that large numbers of affected parties will increase the transactions cost of a bargained solution to the point that marginal externalities, in the Buchanan and Stubblebine sense, are eliminated. This brought forth the admission from Buchanan (66) that the bargaining process would possibly cause the market to move toward the optimal equilibrium, but bargaining costs might prohibit the attainment of full optimality.

Finally, Baumol (72) makes the point that the Pigovian tax is the appropriate mechanism by which to achieve optimality when the bargaining cost of reaching a solution is prohibitive. Baumol states:

Despite the various criticisms which have been raised against it, in the large numbers case, which is of primary importance in reality and to which Pigovian analysis directs itself, his

tax/subsidy programs are generally those required for an optimal allocation of resources. (page 307)¹²

When there can be no private interaction to internalize the technological spillover, the Pigovian unilateral tax prescriptions are appropriate. The assumption that no interaction is possible negates the Buchanan and Stubblebine attack on Pigovian taxes.

Baumol argues in what appears to be an a priori fashion for Pigovian policy the same as Buchanan does against it. The question of when the numbers are too large to allow for a voluntary solution is left unanswered by both writers.

Tracing the literature in this fashion draws the focus on the large/small distinction in the number of affected parties; in the small number case the parties can reach an optimal solution, whereas in the large number case the unilateral Pigovian tax is called for.

However, there is the objection to the type of tax; Baumol's arguments differ from Meade's interpretation of the Pigovian tax. The question of the nature of appropriate tax leads one to question further both the Pigovian tradition and Coase's theorem if in fact they are reconciled in terms of the number of affected parties.

¹²Baumol's disclaimer, "generally," refers to the fulfillment of second order conditions which would affect any solution. In an earlier work (64) he had made the argument that the second order conditions of externality-affected profit maximization would rarely be fulfilled.

Public Versus Private Externalities

Baumol clearly states that his "solution calls for neither taxes upon (the receiving firms), nor compensation to that industry for the damage it suffers," (72, page 311). Kneese and Bower (68) agree that taxing the pollution alone will achieve the social optimum if bargaining is precluded.¹³ However, other writers claim that compensation must be made to achieve the optimum solution.

Baumol's claim is simple. The Pareto conditions require that the price (P_1) in the pollution producing industry reflect both the cost of that good and the cost imposed on the pollution receiving industry; the requirements on price (P_2) in the pollution receiving industry do not show that P_2 should reflect any extra remuneration (in real terms). He says this makes perfectly good sense because the cost of the pollution itself (the smoke) will limit entry into the polluted industry (the laundry). He states:

A high tax rate will discourage smoke and hence encourage migration into the neighborhood. A low tax rate will encourage smoke and, hence, drive residents away. A tax on smoke alone is all that is needed to control the magnitudes of both variables. That is why, as shown by the mathematics of the preceding section, just a tax on the smoke producer is sufficient to produce an optimal allocation of resources among all the activities in our model. (72, page 312)

¹³ Kneese and Bower (68), page 100.

Later on he reports that Coase, in a letter, expresses concern that the tax will not be adjusted if more laundries enter the polluted area. Baumol writes:

But even on this issue Coase's strictures are not necessarily valid. Suppose that a regulator, having no way of calculating the optimal values of the Pigovian tax is, however, able to determine the value of any marginal social damage at any point in time. "Faut de mieux" he therefore sets a tax rate equal to current marginal social damage on the smoke producer. This causes him to reduce his smoke, and so brings more laundries into the neighborhood. The tax is then readjusted to equal the new (higher) value of damage per puff of smoke, more laundries move in, and so on. Will this process of trial and error adjustments of the tax level, always setting it equal to current marginal smoke damage, converge to the optimum of Section II? That is, will the sequence of tax values converge to the optimal Pigovian tax level, and will resource allocation approach optimality? That now seems to be Coase's main question. (page 315)

He then explains that given the usual assumptions of convexities the system will be stable.

However, the mathematical expression of Baumol's model is not constrained to negative externalities and, therefore, implies that the receiver of a positive externality should not have to pay for the reception of such. Meade's article¹⁴ on bees and externalities argues against such a scheme. While both authors agree that the producer of an externality

¹⁴ Meade (52).

should receive treatment by the taxing authority,¹⁵ Meade claims that the receiver of an externality should also pay or receive compensation so that an optimum will be achieved.

Meade uses a number of different models but in his most simple case he has two industries characterized by the following production functions:

$$x_1 = H^1(l_1, c_1, x_2)$$

$$x_2 = H^2(l_2, c_2),$$

where "l" is labor and "c" is capital, and the externality is positive. Both functions are assumed to be linearly homogeneous. A social optimum exists, he asserts, when the value of the marginal social net product is equal to the marginal payment made to each factor. Capital is the hiring factor; hence, its payment is the residual of output less labor's payment. The assumption of homogeneity implies that the summation of elasticities with respect to output and each factor will equal one; i.e.,

$$E_{l_1}^{x_1} + E_{c_1}^{x_1} + E_{x_2}^{x_1} = 1.$$

Meade shows that c_1 must be taxed at the rate of

$$\frac{x_1}{c_1} E_{x_2}^{x_1}$$

¹⁵ Such treatment would be taxation of pollution and subsidization of a positive externality.

in order to be paid the value of its marginal social net product. This result is in direct contradiction to Baumol's conclusions.

Both Baumol and Meade agree that the "producer" of the externality should be compensated or taxed commensurate with the nature of the externality. However, in one model the "receiver" also undergoes treatment by the taxing authority while in the other it is left alone. (Where the taxing authority is unconcerned with the receiver, the magnitude of the externality itself determines the amount of resources expended in the externality receiving industry.)

Even though his analysis discusses the notion of an unpriced factor, Meade's verbal arguments are in terms of atmospheric effects. His terminology and verbal arguments clearly guide the analysis toward a distinction between public and private effects. A paper by Gould (73) takes up Meade's verbal arguments and develops the difference between types of externalities based on their reception characteristics. Gould distinguished between public and private externalities calling private externalities free access (or common-property or non-exclusive) resources. In the normal use of the term, a common access resource is a private good for which property rights are not enforced. Gould's concept of this free access resource is that the receivers of

a positive externality will impose externalities on each other if there is no charge for the resource. While he does not formally state the concept, the implication is clear: the externalities that the receivers impose on one another are the type that are purely pecuniary in normal markets. Because the externality is scarce, optimality requires that it be rationed by price. Conversely, if the externality is not scarce (i.e., public in its reception) no charge is warranted.

Following the article by Gould the profession seems to accept now that there are two levels of distinction in externality theory, even though these two have not been acceptably integrated. Buchanan (73) offers what might be considered a summary of the two. Table I-1 presents Buchanan's taxonomy. A negative externality is assumed: Firm One(s) pollute(s) Firm Two(s). In Buchanan's opinion Cases 1 through 8 characterize all possible states of externality situations. The entries in Table I-1 indicate the Pareto optimality results that Buchanan predicts.

In Case 3, Buchanan seems to grasp the issue of publicness. Here, he seems to be saying that it is the publicness of the reception that causes inefficiency. However, in Case 4, which according to Meade-Gould should be the reciprocal of Case 3, Buchanan drops the notion of public reception.

TABLE I-1
BUCHANAN'S OUTLINE OF EXTERNALITIES

One Firm One One Firm Two	CASE 1 - Bargaining yields efficient solution	CASE 2 - Bargaining yields efficient solution
One Firm One Many Firm Twos	CASE 3 - Inefficiency results due to publicness interaction among Firm Twos	CASE 4 - Inefficiency due to holdout powers of each Firm Two
Many Firm Ones One Firm Two	CASE 5 - Efficiency results with minor bargaining costs	CASE 6 - Efficiency results with minor bargain- ing costs
Many Firm Ones Many Firm Twos	CASE 7 - Inefficiency results due to publicness interaction among Firm Twos	CASE 8 - Inefficiency results due to holdout power of each Firm Two
Firm One(s) Has (Have) Legal Property Right		Firm Two(s) Has (Have) Legal Property Right

He claims it is the free rider problem (or high bargaining costs or the large number question) which causes inefficiency. Holdout power refers to the free rider problem which is not necessarily caused by publicness. The implication of the Meade-Gould analysis is that a unilateral tax on Firm One is appropriate in the public case. Hence, in the case of true publicness of externality reception, if we were to cure the holdout problem in Buchanan's Case 4, bargaining would still yield an inefficient result because Firm Twos receive payments. Furthermore, the mere existence of many externality receivers is not sufficient to cause a failure in bargaining. Clearly, Buchanan has not presented the true ramifications of the concept of publicness. Cases 7 and 8 may have elements of either publicness or privateness, but are inefficiently cured by the market because of the large number problem. It is, therefore, not clear whether Buchanan is referring to the large number problems when he uses the term public or whether he is alluding to Gould's concept of it.

The confusion that arises over the relationship of the Pigovian and Coasian schools leads to doubt about the validity of the Coase Theorem. The question of who should pay in the Pigovian case leads to a question of who should pay in the Coasian case. This then leads to the question of the

efficiency properties of the Coase Theorem when industry adjustments are accounted for.

Industry Adjustments and the Coase Theorem

The most recent literature abounds with mathematical proofs of the Coase Theorem.¹⁶ These proofs are based upon the equality between the first order conditions for Pareto optimality in an economy affected by externality problems and the first order conditions of profit maximization for one-on-one bargaining solutions. However, these efforts to establish the validity of the Coase Theorem are incomplete in their handling of industry adjustments.

The question of long run versus short run industry equilibria has been approached in the literature from time to time, though seldom in a rigorous manner.¹⁷ The pro-Coasian position is expressed aptly by Calabresi:

Various writers--including me--accepted that conclusion (Coase Theorem) for the short run, but had doubts about its validity in the long run situation. . . .

Further thought has convinced me that if one assumes no transactions costs--including no costs

¹⁶The best work to date is by Gifford and Stone (73). Another article by Gifford (74) presents the implied graphical analysis in total profit terms.

¹⁷The exceptions are Tybout (72) and Schulze and d'Arge (74) whose analyses are incorrect. Both find that inefficiency results.

of excluding from the benefits the free loaders, that is those who would gain from a bargain but who are unwilling to pay to bring it about--and if one assumes, as one must, rationality and no legal impediments to bargaining, Coase's analysis must hold for the long run as well as for the short run. The reason is simply that (on the given assumptions) the same type of transaction would also occur to cure the long run ones. (68, page 67)

The other writers referred to by Calabresi are Bramhall and Mills who in criticizing a work by Kamien, Schwartz, and Dolbear (66) point out that:

Under the payments scheme, profits will be larger than they would have been in the absence of intervention and under the fee scheme profits will be smaller than in the absence of intervention. On the usual assumptions about entry and exit, entry will take place in the former case and exit in the latter case. Entry will lower the price of this product relative to prices of other products, and exit will raise it. Thus, relative prices will, in the long run, be different under the payments scheme than under the charges scheme. Since relative prices will differ, the choice between the two schemes is partly a matter of efficiency and not, as Kneese concludes, entirely a matter of equity. (66, pages 615 and 616)

Gifford and Stone (74) attempt to refute this argument by pointing out that under the payments scheme, the payer will only pay if its profits increase.

The problem with these arguments is that they do not really answer the relevant question: Will firm entry lead to inefficient results in externality situations where bargaining is possible? The analysis of Gifford and Stone is confined to the short run profit maximization of two

firms and is ineffective for two reasons. First, their bargaining model does not tell us how the number of firms in each industry react to changes in the bargaining decision of individual firms. Their statement that payment will be forthcoming only if it is profitable may be the answer but Gifford and Stone do not show why. Second, their bargaining model, as an analysis of the short run actions of firms, is not universal. Basically, they assume the result by not telling the reader how the bargainers actually bargain.¹⁸

Various writers have addressed industry adjustments directly, though none have done so correctly. Tybout (72) and Schulze and d'Arge (74) all treat the industry size as a variable. However, because their definition of the externality problem is Pigovian rather than Coasian, their results are incorrect.

On the other hand, Nutter (68) followed by Shapiro (74) uses the correct definition of externality. Nutter points out that the important aspect in the cattle-wheat case of Coase is whether cattle will be raised on a plot of land adjoining wheat production. He recognizes the site-specific nature of the externality problem. The

¹⁸ Their model is only a description of two profit functions which yield the joint profit maximizing results without explicitly assuming a joint profit maximizing model.

importance of rents on these plots is also recognized. Cattle production will only occur next to wheat production, if the "quasi-rents" associated with the two together are at least as great as alternative values of the land.

Nutter concludes his analysis with the statement that the necessary prior existence of rent assures the Coase Theorem. However, Nutter and later Shapiro do not recognize that the rent associated with the pollution generating activity is a variable that adjusts as the industry sizes adjust. As the rent adjusts it guides production toward the efficient solution. It is the competitive adjustment mechanism acting through these rents that is the focus of the proof of the Coase Theorem presented in Chapters V and VI.

Summary

The current externality literature pertaining to the Coase Theorem is incomplete. First, the Coase Theorem is not compatible in a theoretical sense with the Pigovian school even though they address the same problem. This is true even though proponents of both schools admit the validity of the other's arguments in limited circumstances. Second, the validity of the Coase Theorem when industry adjustments are considered stands under a theoretical cloud.

The result of these two problems is that the importance and application of Coase's proposition cannot be fully appreciated.

While there are many similar lines of analysis running through the externality literature there is none which completely integrates the various approaches. Such an outline is the first goal of this dissertation and is the purpose of the next chapter. As shown in later chapters, by combining the large/small numbers classification with the public/private reception dichotomy the arguments of the major contributors will all find a place.

CHAPTER II

AN ALTERNATIVE TAXONOMY

Introduction

The review of the literature shows that there are many ways of viewing externality problems. This chapter integrates two of these. Specifically, the classification scheme of "large or small numbers" of externality affected parties is joined with the classification scheme of "public or private reception." This produces a fourfold outline of externality problems. From this outline the appropriate specifications of the externality can be deduced. These alternative specifications are used to derive Pareto welfare conditions that are consistent with the differing policy prescriptions of Pigou and Coase.

Consider the matrix in Table II-1.

TABLE II-1
OUTLINE OF EXTERNALITIES

Large Number		Small Number	
I		IV	Public
II		III	Private

The purpose of this chapter is to examine the taxonomy in Table II-1. This will be done by, first, analyzing individually the classification schemes of large/small numbers and public/private reception. Attention is paid to the underlying assumptions in each. Then, the various types of externalities are discussed and illustrative examples are offered.

It will be shown in the following chapters that: Type I is the case for which the unilateral Pigovian tax is appropriate; Type II requires a bilateral tax; Type III is the case developed by Coase in his path-breaking article; Type IV is probably unsolvable except by government regulation. Together these four types effectively address all known technological externality problems.

The Large/Small Numbers Classification

The distinction between large and small numbers is one based on transactions costs. In bargaining, there is a potential gain to any party from holding out, which, as the number of parties involved becomes large, results in prohibitively high transactions costs. (This phenomenon is often called the "free rider" problem.¹⁹) The costs of negotiating

¹⁹Actually, there are many variations of the "free rider" concept. We use the term only as indicated above. Also, the term transactions costs is used in the sense of reaching a voluntary agreement where no formal market exists. In addition to the cost resulting from strategic behavior it includes the costs of decision making for each individual, administrative costs, etc.

a voluntary solution will be a function of the number of parties affected. Thus, solutions to technological externality situations will in general depend on the number of participants. We define the small number case as one where these transaction costs are zero, and the large number case as one where they are infinite. Furthermore, it is assumed that while individual transactions costs are infinite in the large number case, the administrative costs of determining and imposing the perfect tax are zero.²⁰ In practice, of course, these definitions are too strict.²¹ However, theoretically they allow the two extremes to be distinguished without cluttering the analysis with a measure of transactions cost.

²⁰In practice the result will always be that the marginal cost of administering a tax and the marginal inefficiency of the tax mechanism employed must be compared to the marginal benefit of its imposition. This assumption merely allows us to use the theoretical concept of a tax as an alternative to the private action of individuals. For an important discussion of taxing methods see Johnson (69).

²¹Note that the free rider problem is not a problem that absolutely prohibits an efficient solution. Even in the case of the free rider problem in pure public goods, the optimal solution is definable and the political mechanism is available to overcome the inability of the market to achieve the Lindahl solution. The Wicksellian rule allows each person's small marginal effect to be important enough for the individual to state his true preferences. The problem is that in the real world the costs of reaching this solution as the number of participants becomes large may be prohibitive. However, some research, notably V. Smith (78), show that the Wicksellian rule may be practicable.

The Public/Private Classification

Public externalities have the property that the reception by one firm does not diminish the amount potentially available to others. The definition is the same as that for public goods presented by Samuelson (54, 55). For externalities this implies that the quantity of the spillover effect received by one firm is not affected by the number of other firms receiving the effects. This is the type of externality assumed by Baumol (72) in his classic factory-laundry example. It is also a common assumption of writers in the Pigovian tradition.

Formally we can write $n_1 y_1 = y_2$, where n_1 is the number of firms in the externality producing industry, y_1 is the amount of the externality produced by each firm, and y_2 is the amount received by each firm in the receiving industry. This specification embodies the public reception characteristics because the amount produced, $n_1 y_1$, is available for anyone to receive. The number of receiving firms, n_2 , does not affect the amount received by any one. The total amount received can, in this case, increase even if $n_1 y_1$ stays constant. As the number of receivers, n_2 , increases the total reception increases.

Note that the measurement of the externality is in terms of the magnitude of the units received. There is no dispersion factor or distance factor, etc., included in the public externality. Clearly, this is a most simplified way of expressing the externality. The vagaries of weather and

other factors are casually dismissed. This is done for two reasons. First, other writers have done this so it is continued here for comparability. Second, we are most concerned with the distinction between public and private. A public externality is one that is available at the same level to all receivers. A dispersion factor only complicates this definition. For instance, if a dispersion factor is included and the externality is negative all receivers will move as far away as possible. If the pollution is received at all it will be received at the minimum level by all firms. The opposite occurs for positive externalities. Thus, the specification $y_2 = n_1 y_1$, though simplified, is appropriate for public externalities. The level $n_1 y_1$ is defined in the same dimension as y_2 merely for convenience.

Private externalities are such that the amount received by one firm does reduce the amount available to others. There are two situations that give rise to a private externality. The simple case is one where the amount received by one firm actually removes externality units from the amount available to others. This situation can be written as $n_1 y_1 = n_2 y_2$. The amount received by one firm is an inverse function of the total number of receiving firms, n_2 . The total amount received is constrained to $n_1 y_1$. In terms of the specification of the externality this situation is identical to a normal market sale of an input by one industry to another.

The other situation that causes the externality to be private is that of locational restriction of the external effects. In some cases, externality effects can be considered to be spatially bounded. The production of an externality at one point spills forth with diminishing impact as it moves away from the origin. For simplicity, assume that the externality is produced in one area, completely fills that area with equal intensity but does not cross over into the next area. Thus, the externality is locationally confined. The importance of this assumption is that the maximum number of firms receiving the externality in one area will be fixed if spatial requirements of firms are positive. In the simplest case, the maximum number is one; the externality is then "one-on-one." Where the number of potential receivers is limited, scarcity of the locations will cause the externality to be private.

Strictly speaking the maximum number of firms in a given area is not fixed. One need only look at the acres of beach and number of hotel rooms in Miami now compared to 100 years ago to find evidence of this. Both are functions of market price. However, for simplicity, it is assumed that locations are perfectly inelastically supplied in a given area and that firms require a fixed amount of space. Thus, the maximum number of firms in any area is fixed.

In the one-on-one case of locational confinement of the spillover, the externality specification is simply $y_1 = y_2$. The amount produced by one firm is identical to that

received by another. Only one firm can receive the effects. Locational restriction of the spillover effects can occur in the large number case by modifying the assumption of "one-on-one" association. For instance, $y_1 \geq Ky_2$ says that the amount of the externality produced by one firm can be received by up to K firms.²²

If the externality is negative there must be a binding constraint on the number of locations for pollution to exist at all. With no limit on locations externality receiving firms would always avoid pollution.

The Various Externality Types

Type I externalities are large number, public reception cases. This is the type implicitly assumed by Baumol in the factory-laundry example. Embodied in this classic example is the assumption that there is such a large number of producers and receivers that bargaining is prohibited. Furthermore, the reception of the effects by one laundry has no effect on the quality of the air and, hence, does not effect the amount of the externality available to others. Baumol does not consider the scarcity of locations within the polluted area. The implicit assumption is that the number of firms receiving the pollution is unconstrained.

²²It should be noted that if K is defined as the maximum number of firms in a given area, the externality is private only if $n_2 > K$.

Type II externalities are characterized by large number and private reception. As noted above, there are two possible causes of the private externality: scarcity of the externality itself or scarcity of locations to receive it. In the estuaries of the southeastern United States, small shrimp grow to nearly commercial size before returning to the ocean where they are harvested. Commercial activities in the estuaries affect the amount of shrimp leaving. The external effects are of the large number type because of the many lease holders of the marsh and the many shrimpers. The externality is private because each shrimp caught is one fewer to be caught by others. Scarcity of locations may be a constraint here due to congestion.

An alternative example of Type II externalities, one embodying locational restriction, is that of bees.²³ The case of bees can be large number or small number, but it is always private. The pollination provided by a swarm is only occurring in the group of trees within the area of the swarm. If the swarm occurs over a large enough area, the externality might be of the large number variety.

Because locational confinement of a spillover causes it to be private, any externality affecting firms that have a plant with large spatial requirements must be

²³The bees and apples externality comes from Meade (52). Assume the externality is a positive one where bee keeping affects the growth of fruit as well as producing honey. We will not consider the bilateral possibilities of this problem, i.e., fruit growing affecting the quantity of honey.

private. For instance, Baumol's example of the factory-laundry is best analyzed as a private externality. Thus, in terms of producers, a realistic example of a purely public externality is hard to find. However, for consumer cases the aesthetic deterioration of tourist areas conforms to the Type I definition.

Type III externalities exist when the number of parties is small enough to facilitate bargaining. This type may exist due to privateness generated by locational restriction or by quantity reduction of the externality due to reception. However, the site-specific nature of the external effects seems to exist even in this latter case. Thus, Type III is always modeled as a locationally confined externality problem. Bees are a good example. The number of trees in the area of the swarm will affect the number of trees covered by the swarm. If the area of the swarm is small, the externality is Type III simply for this reason. Noise is a good example of pure locational confinement. Even though the noise is available at a constant level to all in the immediate area, the immediate area is limited and so is the externality.²⁴

²⁴ Note that in the case of noise we have an example of dispersion associated with multiple locations receiving exactly the same level of the externality. Noise can be thought of as emanating from a point and moving out in concentric circles of decreasing decibel levels. Dismissing the dispersion factor in the one-on-one case assumes that the single reception site is all of the surrounding area from origin to the point where the noise is indistinguishable.

Finally, for Type IV externalities to exist, it is necessary that a small number of firms receive an externality publicly. This means that there must be an unlimited number of firms which could receive the effects, but that in practice the number will be small enough to facilitate bargaining. Type IV externalities are not analyzed in this paper.

Summary

This chapter has introduced and discussed the three-fold outline of externalities used in the remaining chapters. Actually, the outline includes four types but the last type is not important in terms of the reconciliation of the Pigovian and Coasian traditions.

The logical flow of the argument pursued in this research is to develop a taxonomy that includes all known classes of externalities. For the classes outlined by this taxonomy, the alternative externality specifications are then developed. Using these specifications, the Pareto conditions are derived and are compared to the policy prescriptions of Pigou and Coase. This chapter has addressed the first two points in this procedure: the taxonomy has been presented and the externality specifications discussed.

Type I and III externalities offer unique specifications of the spillover effects that are consistent with the categories from which they are drawn. For Type I, $y_2 = n_1 y_1$ expresses the public reception. The large

number aspect has no affect on the externality identity. For Type III, $y_1 = y_2$ embodies both the strict one-on-one locational confinement of the externality and the small number requirement.

Type III externalities have two specifications because there are two possible causes of privateness of externality reception. First, an actual reduction in the quantity of the externality may result from the reception by one firm. This can be modeled as $n_1 y_1 = n_2 y_2$. In the specification this case is identical to a normal market input. It is an externality because of some market failure, for instance, a common access resource. Alternatively, the externality may be Type II because its effects are locationally confined. This specification in the large number case is $y_1 \geq K y_2$. The only difference between this and a Type III externality is that the number K is assumed large enough to prohibit bargaining.

CHAPTER III

THE NATURE OF EXTERNALITY AND EFFICIENCY

Introduction

As previously stated, the main goal of this paper is to reconcile the Pigovian and Coasian approaches to the externality problem. It was suggested in Chapter II that the four type taxonomy of externalities based on the large/small number and public/private reception classification schemes could be used to reconcile these two schools. In order to do so, it is necessary to derive the Pareto welfare conditions for an economy constrained by externality problems of these various types. In other words, by using the technical definitions of the aggregate externality developed in the last chapter, we should be able to generate both Pigou's policy prescriptions as well as Coase's.

This chapter first defines externality production and reception and states the assumptions about the production functions used in this research. Second, a Pareto welfare model is devised that includes externality constraints

consistent with the definition of Types I, II, and III. Finally, the resulting Pareto conditions are discussed.²⁵

Before beginning the analysis, a few words about the general assumptions governing the model are in order. Throughout, only competitive industries are considered. No discussion of any monopoly or otherwise imperfectly competitive situations is undertaken. All firms in an industry are identical and possess U-shaped cost curves so that the number of firms is determinate at the competitive equilibrium. The competitive equilibrium is assumed to exist. Moreover, resources are assumed to be perfectly mobile at zero cost. This assumption has the special application to the relocation of firms in those cases where the externality is site specific. As stated before, in those cases where bargaining costs are assumed zero (the small number case) all possible transactions are included.

Externality Production

In the production of externalities the quantity of output and the quantity of the externality are treated as joint products of the application of some set of resources.

²⁵Actually the Pareto conditions for Type III externalities will not appear at this point to be completely representative of Coase's arguments. This relationship is developed in Chapters IV and V.

Consider the following implicit production function²⁶
for the externality producer:

$$f^1(q_1, y_1, x_1, \dots, x_n) = 0$$

In this production function, " q_1 " is the normal output of the firm, " y_1 " is the amount of the externality produced, and " x_1, \dots, x_n " are the amounts of the inputs one through n . Ignoring any effects on y_1 , we assume that $f^1(\cdot)$ is such that $\partial q_1 / \partial x_i$ follows the normal assumptions of increasing and then decreasing returns for all $i = 1 \dots n$.²⁷ This assumption generates the normal U-shaped short run cost curves.

The simplest relationship between q_1 and y_1 , can be found by taking the total differential of the production function, dividing through by dq_1 , and setting all dx_i/dq_1 equal to zero. This yields:

$$1) \quad \partial y_1 / \partial q_1 = -f_q^1 / f_y^1$$

The sign of $-f_q^1 / f_y^1$ is assumed to be non-negative. If the sign of this term is positive, it implies that an increase

²⁶Whitcomb (72) has argued that the production function specification used here offers too many degrees of freedom. He claims the appropriate specification for the externality producing firm is

$$q = f(x_1, \dots, x_n)$$

$$y = h(x_1, \dots, x_n)$$

This specification does not allow for a tradeoff between q and y holding all x_i constant. However, as shown in the text, the more general specification includes his case and yields the same results.

²⁷This assumption is made for both producers and receivers of externalities. Hence, the convexity of the production constraints for the economy is assured at the point of competitive equilibrium.

in q_1 increases y_1 while holding all x constant.²⁸ If $-f_q^1/f_y^1$ is zero, the good and externality are fixed proportion joint products. The constrained profit function of a firm which faces the prices $\{P_q, P_y, R_i, i=1 \dots n\}$ for its output, externality²⁹ and inputs, respectively, is:

$$\pi = P_q q_1 + P_y y_1 - \sum_i R_i x_i + \phi f^1(q_1, y_1, x_1, \dots, x_n)$$

Profit maximizing conditions imply the following:

$$2) \quad R_i = P_q (\partial q_1 / \partial x_i) + P_y (\partial y_1 / \partial x_i),$$

$$i = 1 \dots n.$$

The profit maximizing firm producing an externality for which it confronts a marginal price (positive or negative) will sum the marginal revenue products of the output and externality and set this equal to the price of each input. If we simplify the analysis at this point by considering only one input, the terms $\partial q_1 / \partial x_i$ and $\partial y_1 / \partial x_i$ in Equation 1 become dq_1 / dx_1 and dy_1 / dx_1 . Rewriting, we have

$$P_q = R / (dq_1 / dx_1) - P_y (dy_1 / dq_1)$$

where R is the price of the single input. The term $R / (dq_1 / dx_1)$ is the marginal cost of output; $P_y (dy_1 / dq_1)$ is the value an incremental unit of q_1 has through its

²⁸Air pollution produced by cars tends to exhibit this property. The timing advance can be changed decreasing pollution as well as output (miles per gallon).

²⁹ P_y may be considered to be a tax, a subsidy, or a bribe paid by another firm.

effect on y_1 . If y_1 is a negative externality and the firm is forced to pay the marginal cost of this pollution, P_y would be negative. The term $-P_y(dy_1/dq_1)$ would shift up the marginal cost curve of the firm forcing a lower level of production of q_1 . This shift is shown in Figure III-1.

Externality Reception

The characteristics of the effect of the externality on the receiving firm are the same as any other input, except that the effect may be either to decrease or to increase output depending on the sign of the externality. We may write the general production function for the receiving firm as:

$$f^2(q_2, y_2, x_1, \dots, x_n) = 0.$$

The term " q_2 " is the output of the firm; " x_1, \dots, x_n " are the normal inputs; " y_2 " is the quantity of the externality received from some other firm. As indicated the effects of the externality are treated like another input in the function $f^2(\cdot)$. Because there is only one output, $f^2(\cdot)$ can be written in explicit form,³⁰ i.e.,

$$q_2 = F^2(y_2, x_1, \dots, x_n) = f^2(\cdot).$$

The partial of $f^2(\cdot)$ with respect to each x_i is assumed to follow the normal assumptions of increasing and then decreasing returns. The sign of the term $\partial q_2 / \partial y_2 = -f_y^2 / f_q^2$ defines the type of externality, positive or negative.

³⁰The implicit production function form is used only for symmetry in the derivation of the Pareto conditions.

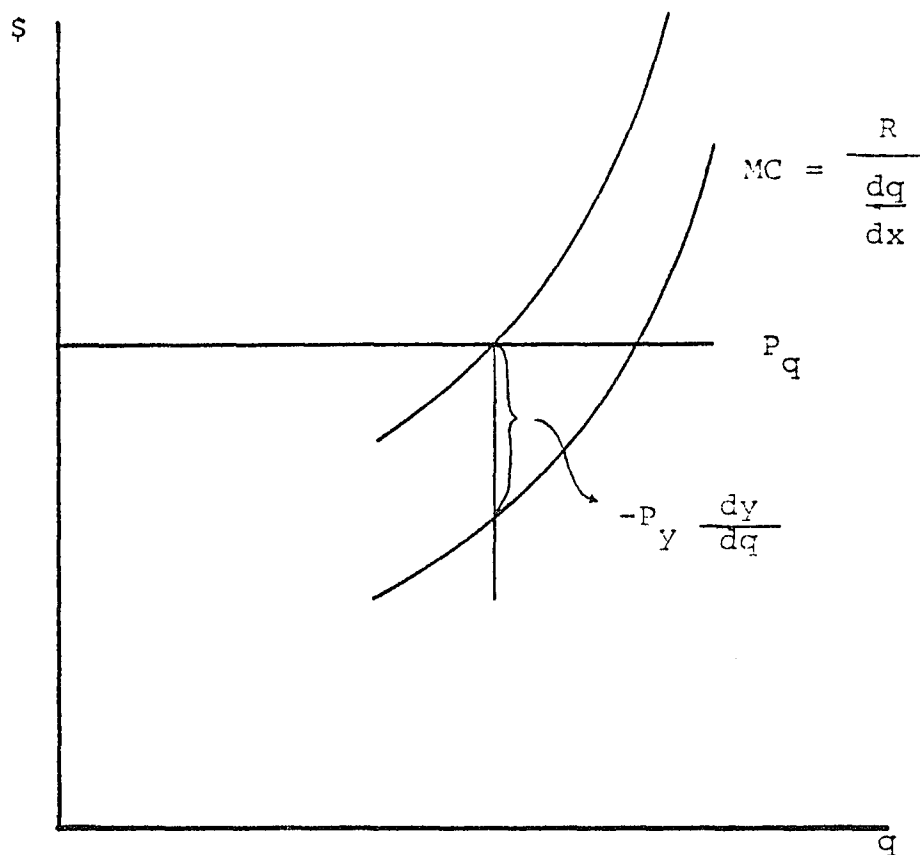


Figure III-1

If $\partial q_2 / \partial y_2$ is zero, no relevant externality exists at that point. It is assumed that $\partial^2 q_2 / \partial y_2^2 < 0$ for positive externalities and > 0 for negative externalities.³¹ The constrained profit function of the externality receiving firm where y_2 is unpriced and where the firm has no control over y_2 :³²

$$\pi = P_q q_2 - \sum_i R_i x_i + \phi f^2(q_2, y_2, x_1, \dots, x_n).$$

Because $\partial \pi / \partial y_2 = \phi f_y^2$, and $\phi = -P_q / f_q^2$, we find that $\partial \pi / \partial y_2 = P_q \partial q_2 / \partial y_2$. As expected, the marginal value of y_2 (its effect on profits) is the rate at which it increases output measured in terms of the price of output.

The term $\partial x_i / \partial y_2$ is assumed to be zero for all $i=1 \dots n$. The externality will either increase or decrease the output of q_2 holding the other inputs constant but it will

³¹Although there are many other ways of looking at the effect of the externality (especially in terms of shifts in the cost curves), these will not be important for later derivations and are dismissed here. For discussions of the issue of separability see, e.g., Davis and Whinston (62) and Dusansky and Kalman (72).

³²Because we treat the receiving firm as unable to directly control the quantity of the externality, it is not necessary to consider the externality effect with a nonzero price.

not affect the quantity of the other inputs.³³ This treatment is consistent with the notion that the externality is treated simply as another input, albeit one over which the firm may have no control.

The Model

The purpose of the Pareto welfare models presented in this chapter is to derive the efficiency conditions for Type I, II, and III externalities. The specification of the aggregate externality constraint forms the difference between the three models and, hence, constitutes the difference in the efficiency conditions.

³³The limitation of treating the externality such that its effect is only felt on output is that it may be more realistic to hypothesize that one or more of the inputs are the media for the introduction of the externality. In this case $\partial y_2 / \partial x_i$ may not be zero for some $i=1\dots n$. If we assume that $\partial y_2 / \partial x_i$ is greater than zero for some i , then the result is that more of the resource is used if f_y^2 / f_q^2 is positive and less is used if the externality is negative.

Another possible assumption might be that the externality affects the quantity of one of the resources, where the resource is measured in efficiency units. If $\partial x_i / \partial y_2$ is not equal to zero the effect shows up as an increased value of $\partial \pi / \partial y_2$. Where previously the value of y_2 was the value of the direct effect of y_2 on q_2 , it now includes both this effect and the value of the marginal product of the i th resource times $\partial x_i / \partial y_2$. In other words, if the externality is positive, not only will it increase q_2 itself, but it will also increase the efficiency units of x_i and thereby increase q_2 .

We do not consider these last two amendments to the assumptions concerning the production function of the externality receiving firm because first, they are not directly associated with the objectives of this research; and second, they would involve much more elaborate derivations later in this chapter.

Production

Consider two industries composed of n_1 and n_2 firms respectively. Industry one is the externality producing industry; industry two is the receiving industry. Thus, the externality is one way. Firms in the same industry are identical in terms of their production functions and purely competitive in terms of their behavior. Industry output is equal to the number of firms in the industry times the output of a firm. Assuming only one input, production functions for representative firms of each industry are shown in Equation Set 3.

$$3) \quad f^1(q_1, y_1, x_1) = 0, \text{ and } f^2(q_2, y_2, x_2) = 0$$

These production functions are assumed to be convex in the region of welfare maximization.³⁴

The specification of the aggregate externality identities was developed in Chapter II. The aggregate amount of the externality produced and received in the Type I case (large number, public reception) can be expressed as $n_1 y_1 = y_2$. The aggregate externality identity for externalities of Type II (large number, private reception) is $n_1 y_1 = n_2 y_2$ where the externality is private because the quantity of the externality is reduced by reception. For Type III externalities (private reception, small

³⁴This assumption is no stronger than assuming the existence of a competitive equilibrium given the previous assumptions made about the production functions.

number) the specification is simply that the externality produced by a firm in industry one is necessarily received by one and only one firm in industry two, i.e., $y_1 = y_2$. Type II externalities that are private because of the locational confinement of the spillover will be analyzed by means of the model used for Type III externalities.³⁵

In these specifications, it is assumed that all firms produce and receive the external effects. Some writers, notably Baumol (72), allow for the externality to be avoided. However, the results are predictable for Type I externalities. The interested reader is directed to Baumol's paper. For the locationally confined externality, avoidance is an important consideration, one addressed in depth in Chapters IV and V.

An additional constraint must be included to ensure that in the case of negative spillovers the Type III externality exists. The number of firms in each industry is assumed to be equal and limited.³⁶ That is, $n_1 = n_2 = S$,

³⁵Recall the externality specification in this case: $y_1 \geq Ky_2$. Pareto optimality will require this constraint to be solved as an equality. K is a constant and can be omitted from explicit consideration.

³⁶The concern in this chapter is with the Pareto conditions on the firms receiving and producing the externality. The assumption that all firms in the two industries are externality related is a simple method of addressing only this point. The inclusion of an upper limit, S , on the number of firms in each industry is done for logical consistency in the negative externality case. In the positive externality case, firms in the two industries will seek to locate near one another. However, in this case the constraint on the maximum number of firms may be lifted.

where S is the fixed number of firms in each industry. A negative Type III externality will only exist if alternative locations are not available. If available, alternative locations would allow the potential pollution receiving firms to avoid the externality. Given a sufficient number of such locations, no firm in industry two would receive pollution.³⁷

Consumption

Assume there are L consumers in the economy who do not experience directly the pollution. The utility function of the j^{th} consumer can be specified as:

$$U^j = U^j(Q_{1j}, Q_{2j}, x_{3j})$$

where " Q_{ij} " is the amount of the i^{th} good consumed by individual j , and " x_{3j} " is the amount of the resources, X , consumed. The constrained utility function of consumer j is:

$$U_C^j = U^j(\cdot) - \lambda_j (P_1 Q_{1j} + P_2 Q_{2j} - P_3 (\bar{x}_{3j} - x_{3j}))$$

where " \bar{x}_{3j} " is the initial endowment of the resource to the j^{th} consumer, " P_1 ," " P_2 ," and " P_3 " are the market prices of Q_1 , Q_2 , and X , respectively, that are faced

³⁷ It is this aspect of the Type III case that is most important in interpreting the results of this research vis-a-vis the results of other writers.

parametrically by the j^{th} consumer, and λ_j is the Lagrangian multiplier on the income constraint. By maximizing this function, we obtain the familiar result that

$$U_i^j = \lambda_j P_i, \quad i = 1, 3.$$

For the economy, it must be true that

$$Q_i = \sum_j Q_{ij}, \quad i = 1, 2.$$

and

$$X = \sum_j \bar{x}_{3j} = n_k x_k + n_2 x_2 + \sum_j x_{3j}.$$

Pareto Optimality

The large number, public reception externality model, which will henceforth be named Model I, has the following constrained Pareto welfare function:³⁸

$$\begin{aligned} \Omega = & \sum_j \omega_j (U^j(\cdot) - g_j) \\ & + \sum_i \mu_i n_i f^i(\cdot) \\ & + \sum_i \rho_i (n_i q_i - \sum_j Q_{ij}) \\ & + \rho_3 (X - \sum_i n_i x_i - \sum_j x_{3j}) \\ & + \psi (n_1 y_1 - y_2) \end{aligned} \quad i = 1, 2; j = 1, L$$

³⁸The terms ω_j , μ_i , ρ , and ψ are Lagrangian multipliers. Because all firms in each industry are identical, $n_i f^i(\cdot) = \sum_{j=1}^{n_i} f^i(\cdot)$, where n_i denotes the number of firms in the i th industry.

The term " g_j " is the utility constraint of the j^{th} consumer in accordance with definition of Pareto welfare.

By replacing the last constraint, the externality identity, with $\psi(n_1 y_1 - n_2 y_2)$, we have the Pareto welfare function for large number, private externalities which are not locationally confined (Model II). Finally, Model III requires the substitution of $\psi(y_1 - y_2) + \phi(S - n)$ for the last constraint and n for n_1 and n_2 elsewhere in the equation. Privately received, large number externalities that are locationally confined can be analyzed by means of Model III.

In order to derive the first order conditions of Pareto optimality, the function Ω is maximized L times each time setting a different λ_j equal to one and g_j equal to zero. This generates a system of $L(4L + 13)$ equations for Model I. All L sets of these equations are similar in form; the value of the equations may be different and, hence a simultaneous solution is necessary to achieve Pareto optimality.³⁹ Maximizing the system for a typical consumer (holding all other consumers' utility constant and satisfying all constraints exactly) yields the following set of equations. These equations are essentially the same except for the partials with respect to industry size. Hence, the derivations are carried out for Model I only.

³⁹See Cliff Lloyd (67, page 252). The use of w_j and g_j to simplify the welfare maximization derivations comes from Baumol (72). Specifications similar to the one used here can be found in Schulze and d'Arge (74), Howrey and Quandt (68), and Myers and Weintraub (71), especially with regard to the industry size and welfare maximization techniques.

$$4) \quad \partial\Omega/\partial s_i = \omega_j U_i^j - \rho_i = 0 \quad i = 1, 3, \quad j = 1, L$$

where $s_i \equiv i^{\text{th}}$ argument in $U^j(\cdot)$

$$5) \quad \partial\Omega/\partial q_i = \mu_i n_i f_q^i + \rho_i n_i = 0 \quad i = 1, 2$$

$$6) \quad \partial\Omega/\partial y_1 = \mu_1 n_1 f_y^1 + \psi n_1 = 0$$

$$7) \quad \partial\Omega/\partial y_2 = \mu_2 n_2 f_y^2 - \psi = 0$$

$$8) \quad \partial\Omega/\partial x_i = \mu_i n_i f_x^i - \rho_3 n_i = 0$$

$$9) \quad \partial\Omega/\partial n_1 = \rho_1 q_1 + \psi y_1 - \rho_3 x_1 + \mu_1 f^1(\cdot) = 0$$

$$10) \quad \partial\Omega/\partial n_2 = \rho_2 q_2 - \rho_3 x_2 + \mu_2 f^2(\cdot) = 0$$

Because all L sets of equations are similar in form, it can be shown that the Pareto requirements on price in the two industries hold in general and are not affected by the income distribution.⁴⁰ Moreover, because the supply and demand functions of consumers and firms are homogeneous of degree zero with respect to the prices of good one, good two, and the resource (i.e., P_1, P_2, P_3) according to Walras' Law, the specification of any one uniquely

⁴⁰This means that in the derivations to come, the choice of the $\omega_j=1$ and $g_j=0$ will not affect the Pareto requirements. In fact, the same results are implicitly derived L times. This does not mean that the Pareto "solution" is invariant with respect to the distribution of income, nor will relative prices be. Relative prices and the composition of consumption will be invariant with respect to the distribution of factor endowments or income if and only if all preference functions are identically homothetic. See Samuelson (58).

determines the other two. Hence, fixing the price of the resource allows us to determine P_1 and P_2 .

Substituting the ω_j term into the first order conditions for utility maximization by the L consumers, we have that

$$11) \quad \omega_j U_i^j = \omega_j \lambda_j P_i, \quad i = 1, 3, \quad j = 1, L.$$

Combining Equations 11 and 4 we have

$$12) \quad \rho_i = \omega_j U_i^j = \omega_j \lambda_j P_i, \quad i = 1, 3, \quad j = 1, L.$$

From Equations 5 and 8

$$\rho_3 = -\rho_i (f_x^i / f_q^i), \quad i = 1, 2$$

Substituting for f_x^i / f_q^i

$$\rho_3 = \rho_i \{dq_i/dx_i + (f_y^i / f_q^i) (dy_i/dx_i)\}, \quad i = 1, 2$$

Solving for the term f_y^i / f_q^i from Equations 5, 6, and 7

$$f_y^1 / f_q^1 = -[(\rho_2 n_2) / \rho_1] f_y^2 / f_q^2$$

Noting that $dy_2/dx_2 = 0$ and $f_y^2 = 1$ by definition (see page III-6) we have

$$13) \quad \rho_3 = \rho_1 (dq_1/dx_1) - \rho_2 n_2 f_y^2 (dy_1/dx_1)$$

$$14) \quad \rho_3 = \rho_2 (dq_2/dx_2)$$

Substituting $\{\omega_j \lambda_j P_i, \quad i = 1, 3\}$ from Equation 12 for

$\{\rho_i, i = 1, 3\}$, cancelling $\omega_j \lambda_j$, and rewriting

$$15) \quad P_1 = P_3 / (dq_1/dx_1) + P_2 n_2 f_Y^2 (dy_1/dq_1)$$

$$16) \quad P_2 = P_3 / (dq_2/dx_2)$$

Substituting for ψ and for $\{\rho_i, i = 1, 3\}$ in Equations 9 and 19, and cancelling

$$17) \quad P_1 q_1 - (P_2 n_2 f_Y^2) y_1 = P_3 x_1$$

$$18) \quad P_2 q_2 = P_3 x_2$$

Equations 15 and 16 can be interpreted as the marginal cost-price equality necessary to achieve Pareto optimality. Equations 17 and 18 are the zero profits conditions that ensure the appropriate number of firms in each industry and thereby specify the point in the marginal cost curve that yields Pareto optimality.

Equations 17 and 18 can be written in average cost form.

The derivation of the Pareto conditions for Model II require that the constraint $\psi(n_1 y_1 - n_2 y_2)$ be substituted for $\psi(n_1 y_1 - y_2)$. Equations 7 and 10 are changed to

$$7') \quad \mu_2 n_2 f_Y^2 - \psi n_2 = 0$$

$$10') \quad \rho_2 q_2 - \psi y_2 - \rho_3 x_2 + \mu_2 f^2(\cdot) = 0$$

This change in Equation 7 causes the n_2 term in Equations 13, 15, and 17 to fall out. The change in Equation 10 causes $(P_2 f_Y^2) y_1$ to appear on the left-hand-side of Equation

18. Thus, the extra term $\{P_2(\partial q_2/\partial y_2)(y_2/q_2)\}$ appears in Table III-1, under the average cost conditions for industry two.

For Model III $\psi(y_1 - y_2)$ is substituted for $\psi(n_1 y_1 - y_2)$ and "n" is substituted for n_1 and n_2 . The additional constraint $\phi(S-n)$ is necessary for consistency. Equations 6 and 7 become

$$6") \quad \mu_1 n f_Y^1 + \psi = 0.$$

$$7") \quad \mu_2 n f_Y^2 - \psi = 0.$$

Because n now appears in both Equations 6" and 7" it cancels and Equations 13 and 15 are the same in Model II. Equations 9 and 10 become simply

$$9") \quad \rho_1 q_1 + \rho_2 q_2 - \rho_3 x_1 - \rho_3 x_2 + \mu_1 f^2(\cdot) + \mu_2 f^2(\cdot) + \phi = 0.$$

The value of the Lagrangian multiplier ϕ is the imputed value of the scarce locations n, in Model III.

Table III-1 summarizes these conditions for all three models.⁴¹ Recall that Type I is the Pigovian case and Type III is the Coasian case. However, the marginal cost conditions in all three models are essentially identical. It is the average cost requirements that delineate the differences in the results.

⁴¹The equation numbers from the text are shown in parentheses in the table.

Table III-1

Pareto Efficiency Conditions for
Externalities of Type I, II, and III

<u>Model I</u>		
	Industry One	Industry Two
Marginal Cost	15) $P_1 = P_3 / (dq_1/dx_1)$ $-P_2 n_2 (\partial q_2 / \partial y_2) (dy_1/dq_1)$	16) $P_2 = P_3 / (dq_2/dx_2)$
Average Cost	17) $P_1 = P_3 x_1/q_1$ $-P_2 n_2 (\partial q_2 / \partial y_2) (y_1/q_1)$	18) $P_2 = P_3 x_2/q_2$

<u>Model II</u>		
	Industry One	Industry Two
Marginal Cost	$P_1 = P_3 / (dq_1/dx_1)$ $-P_2 (\partial q_2 / \partial y_2) (dy_1/dq_1)$	$P_2 = P_3 / (dq_2/dx_2)$
Average Cost	$P_1 = P_3 x_1/q_1$ $-P_2 (\partial q_2 / \partial y_2) (y_1/q_1)$	$P_2 = P_3 x_2/q_2$ $+P_2 (\partial q_2 / \partial y_2) (y_2/q_2)$

<u>Model III</u>		
	Industry One	Industry Two
Marginal Cost	$P_1 = P_3 / (dq_1/dx_1)$ $-P_2 (\partial q_2 / \partial y_2) (dy_1/dq_1)$	$P_2 = P_3 / (dq_2/dx_2)$
Average Cost*	$P_1 = P_3 x_1/q_1$ $+(\phi - (P_2 q_2 - P_3 x_2))/q_1$	$P_2 = P_3 x_2/q_2$ $+(\phi - (P_1 q_1 - P_3 x_1))/q_2$

*This condition is best stated as a zero profits requirement
 $\sum_{i=1}^2 (P_i q_i - P_3 x_i) - \phi = 0$, where ϕ is imputed rent on each location

The marginal cost conditions in all three models show that the externality producing industry should explicitly recognize the effect of the externality and the receiving industry should merely take the externality as a given. For industry one, marginal cost of q_1 should be the additional cost of the resource necessary to produce an additional unit of q_1 plus the additional cost of producing q_2 caused by an additional unit of q_1 . In Model I, $P_3/(dq_1/dx_1)$ is the additional cost of the resource; $-P_2n_2(\partial q_2/\partial y_2)$ (dy_1/dq_1) is the additional cost imposed on the production of q_2 . For industry two, there is no explicit accounting for the effect of the externality. $P_3(dq_2/dx_2)$ is the additional cost of the resource necessary to produce an additional unit of q_2 . However, the term (dq_2/dx_2) implicitly reflects the effect of the externality, as discussed in the third section of this chapter.

The average cost conditions for the three models differ significantly. In Model I, firms in the externality producing industry must, in their average cost, explicitly account for the effect of the externality on the receiving industry. The "price"⁴² of the externality is the term $-P_2n_2(\partial q_2/\partial y_2)$. This term times the amount of the externality should be an actual payment made by each firm in industry one if a Pigovian tax is used to achieve optimality. On the other hand, no explicit accounting

⁴²This price is positive or negative depending on the negative or positive sign of the externality, (dq_2/dy_2) .

should be made by the firms in industry two. To paraphrase Baumol (72, page 312), the level of the externality acting through the marginal and average costs of the firms will optimally delimit the number of firms in the receiving industry. Hence, the results of Model I are consistent with the Pigovian taxing strictures discussed by Baumol.

Alternatively, Model II shows a case where the externality receiving industry must account explicitly for the externality. The term $P_2(\partial q_2/\partial Y_2)$ appears in the average cost requirements of both the producing and receiving firms. This term times the amount of the externality for each firm and summed over all the firms in each industry constitutes a transfer from one industry to the other; i.e., $n_1(P_2(\partial q_2/\partial Y_2)Y_1) = n_2(P_2(\partial q_2/\partial Y_2)Y_2)$ because $n_1Y_1 = n_2Y_2$. The direction of the transfer depends on the sign of the externality. If the externality is negative, industry one pays industry two; if positive, industry two pays industry one. This result is identical to the case of a normal good that is produced as a joint product and used as an input in another production process. This result is consistent with the Pigovian tax strictures suggested by Meade and Gould. Recall that Meade argued that a tax and subsidy scheme was necessary as opposed to a unilateral tax (assuming a negative externality).

In Models I and II the average cost condition determines how many firms should exist in each industry. The

average cost conditions determines where along the appropriately specified marginal cost curve each firm should operate. Industry quantity demanded divided by the quantity produced by one firm yields the optimal industry size in terms of the number of firms.

In Model III industry size in the sense of the number of firms is fixed at S . This specification is used because pollution will not exist otherwise. Thus, the average cost conditions are not important in determining the number of firms.

While the average cost conditions for Model III are unimportant as a condition of efficiency, they are descriptive about the nature of the Coasian externality problem. These average cost conditions states together as a zero profit constraint show the value of ϕ as the rent on each location. These conditions are best stated as $\sum_{i=1}^2 (P_i q_i - P_3 x_i) = \phi$. If the marginal cost conditions are satisfied, and if the location constraint is binding, ($n = S$), the rent is a residual. The value of ϕ is the value of the increase in welfare if S were increased. Its monetary value can be computed by taking the difference between the total revenues and resource cost for both the externality producing and receiving firms at one location where the marginal conditions are satisfied.

It will be shown in Chapter V that the marginal cost conditions from Model III imply that the two firms must jointly maximize profit. If pollution cannot be avoided,

the average cost efficiency conditions show that the two involved firms make profit equal to ϕ . If they are autonomous, as Coase illustrated, it matters not which one has the property right to pollution because a rent, ϕ , must exist. A payment can flow in either direction without affecting efficiency. However, Model III does not do justice to the Coasian case because the externality specification assumes that pollution must occur if production does. Results consistent with the Coasian case are only achieved if the location constraint is binding.

If a Type II externality exists because the number of locations is fixed, the efficiency conditions are given by Model III. The full implication of these results will be explored in Chapter V. However, the implication from the results obtained thusfar indicates that both the pollution receiver and producer should pay. Notice that such a tax scheme is not part of the Pigovian tradition. In fact Baumol makes a point of criticizing Coase's suggestion that possibly such a tax might be necessary. Coase and Buchanan both thought that such a tax might be appropriate but were unsure.

⁴³The reader may wonder whether a positive payment is always possible in either direction. This is a question of the possibility of corner solutions. Such questions are extensively addressed in the next two chapters. As a preview, it can be shown that the payment will always equal the difference between total revenues and resource cost for the firm making the payment.

Summary

This chapter has defined the externality problem in terms of the specification of the production functions of the firms in the economy. For simplicity only a one way externality is considered: firms either produce or receive external effects. For the producing firm, the externality is a joint product of its output; for the receiving firm, the externality is like another input except that the firm may not be able to control the amount.

In order to consider the aggregate effect of the externality, three models were used. These models are specified in such a way as to conform to the definitions of Type I, II, and III externalities. The Pareto welfare conditions of these models were derived and shown to conform with the policy suggestions of both the Pigovian and Coasian traditions.

Models I and II show results consistent with those of Baumol, Meade, and Gould. The imposition of a Pigovian tax is an appropriate technique for achieving efficiency. The tax differs in the two cases. In Model I such a tax should be unilateral; in Model II a tax/subsidy scheme is necessary.

The welfare conditions derived from Model III can be shown to imply that profit maximization alone will achieve optimality. A negative externality will only exist if locations are scarce. This scarcity calls for a rent that means a payment between two autonomous firms can go in

either direction. This result is consistent with Coase's arguments. This result also implies that the appropriate tax in the large number case where the externality is locationally confined is one where all parties pay.

In the following chapters, Model III will be amended to more closely reflect the conditions of the Coasian externality problem. Specifically, the model is extended to allow for the existence or avoidance of pollution at any particular site. With this extended model it will be shown how the rents, which are the essence of the Coasian Theorem, adjusts in order to achieve the optimal industry mix.

CHAPTER IV
PARETO EFFICIENCY
IN THE SMALL NUMBER, PRIVATE RECEPTION CASE

Introduction

The results of the previous chapter indicate that the Pigovian and Coasian arguments can be reconciled. The Pareto conditions of Model I and II are appropriate for certain kinds of Pigovian problems; the taxing policies are consistent with those proposed by other writers. Model III shows results which, although simplified, are appropriate when locational restriction of the external effects occurs. This chapter extends the analysis of site-specific externalities by allowing for the externality to be avoided at some locations. The extension of the analysis to include the existence of pollution at some locations and not at others greatly increases the application of the model.

The site-specific externality analyzed by Model III gave rise to the Pareto welfare result that economic rents exist if locations are scarce. This finding has immediate policy implications that are consistent with the Coase Theorem. Specifically, these policy implications are: 1) government intervention is not necessarily when technological externalities exist if the firms maximize

profit; 2) definitions of property rights will only decide the payments going to various landlords and will not affect the quantity or mix of production; and, 3) the property right definition that occurs through governmental inaction is as efficient as any other; Pareto optimality is achieved even if property rights are given by default to the polluter through government inaction. If the Coase Theorem is true, government interest in defining property rights is justified only when equity is a concern.

The results obtained from Model III in the last chapter show that a shadow price on each location is necessary when locations are scarce.⁴⁴ This shadow price has the economic interpretation of a rent. The proof of the Coase Theorem hinges on two points. First, this economic rent must exist in the case of pollution.⁴⁵ Second, the rent at each location is a variable. It changes as the industry output levels vary. This second point is the key to the Coase Theorem ignored by the current literature.

In order to develop the proof of the Coase Theorem, this chapter reexamines the Pareto efficiency conditions for Coasian externality problems. The constraint on

⁴⁴In other words, where the constraint on the maximum number of locations is binding.

⁴⁵We are for the most part concerned only with negative externalities. When the theory is fully developed for these, the case of positive externalities becomes transparent.

locations is modified to allow for pollution at some locations and not at others. This modification brings the model more in line with the examples and applications of the theorem used by Coase and others. In many of the Type III externality cases one finds that firms in the industries involved in the externality do not always locate near one another. In other words, some firms avoid the pollution problem while others are not so lucky. This chapter expands the welfare model to include this phenomenon and derives the Pareto conditions. In the next chapter the competitive mechanism is shown to generate these efficiency properties.

The Relevance of the Small Number Setting

The small number case of externality relationships is relevant whenever participants can reach a mutually beneficial solution to the spillover problem if such a solution exists. Coase (60) describes several examples that are consistent with the definition of the Type III externality. The confectioner versus the doctor, the cocoa-nut fibre weaver versus the sulphate of ammonia producer, and a brewer versus an innkeeper are all cases of firms interlocked in externality problems having bargainable solutions.

An initial reaction to these examples is that they are insignificant in terms of the relevant industries as a whole. Isolated cases of externality are not likely to have a significant impact on the price in any market because,

in a competitive market, firms are price takers. It is unusual that all of Coase's examples seem to be locational anomalies which are not characteristic of the particular industries as a whole. However, the Coase Theorem does indeed apply even in these cases and its application is far from trivial. An important aspect of the theorem developed in this and the following chapter is that firms should locate and relocate based on the external effects produced and received.⁴⁶ In this context the Coase Theorem may imply that no pollution should exist at any one or, in fact, all locations. Hence, Coase's examples are consistent with his theorem.

Moreover, there are two examples where the small number case has industry-wide implications. The first is the famous case of the apple and bees externality used by Meade (52). Certainly here we have two industries⁴⁷ where the externality relationship is industry-wide. The second case deals with the shellfish industry. Commercial clamming in the estuaries of the southeastern United States using mechanical harvesting devices may result in externalities that influence the production of other

⁴⁶This result can be extended to firms of multiple industries, so that the externality relationship of any firm in one industry may not be exactly the same as that of any other firm in that industry. This point is addressed in Chapter VI.

⁴⁷At least, many other types of agricultural endeavors require the service of bees. See especially, Cheung (73) and Johnson (73).

commercial seafood. Specifically, the interdependencies between oystering and clamming embody properties of the small number case. Because most clamming and oystering occurs in the same areas, the externality relationship is significant in terms of industry production.⁴⁸

Another example of the presence of Type III externalities is the emergence of zoning ordinances. Although many of these regulations pertain to consumers, the wide variety of commercial zones suggest significant externalities of location among firms as well.⁴⁹ An obvious question is whether the zoning ordinances are a necessary means to achieve efficiency or are merely rent transfers obtained through the political market.

The Extended Specification

Model III from the last chapter is essentially the same here. The externality is a "one-on-one" locational relationship between two firms.⁵⁰ If the externality

⁴⁸It has been pointed out by Johnson (73) that any externalities which exist in the bee industry are effectively internalized. Likewise, Maloney et. al. (77) claim that the oyster-clam problem is internalized if market processes are permitted to function. It is the purpose of this paper to prove why market forces will necessarily internalize externality in these cases.

⁴⁹Shopping centers are a good example of private market internalization.

⁵⁰This simplification can be easily modified without changing the results. Such a modification is necessary when considering the application of Model III to Type II externalities. This discussion is deferred, in part, to Chapter VI.

effect produced by a firm in industry one is received by a firm in industry two, it is received by only one such firm. However, there is no argument in the production function that requires a firm in one industry to locate in the proximity of a firm in the other industry. Thus, Model III can be simply extended to allow for avoidance of the externality. The aggregate externality constraint used here will include isolated as well as joint production of the two goods. Still assuming that there are S locations and two sites at each, we now allow for one site to remain vacant. Whereas in Chapter III the number for firms in the two industries was assumed equal, this is no longer the case. Some locations may house only firms in industry one, some only firms in industry two, and some may house a firm from both industries. However, only one firm from an industry may produce at a location.⁵¹

Although the Type III externality was developed in the last chapter, a review of that discussion in light of the extended model may be enlightening. As we will see, the extension implies efficient outcomes that may include pollution at some locations and not at others. In fact,

⁵¹Even though there are two sites, only one is available to each industry. This assumption is equivalent to assuming pollution may or may not exist at a location.

as in Coase's examples, efficiency may require that no firm actually receives pollution.⁵²

In this model, the private nature of a Type III externality is embodied in the "one-on-one" nature of externality production and reception. One firm produces exactly what another receives; hence, $y_1 = y_2$. That this is a private externality situation is obvious for positive externalities. When a firm in industry two receives the effects of a positive externality from a firm in industry one, no other firm in industry two can receive those benefits. The externality is private because it is excludable. Symmetrically, if the externality is negative, the avoidance of the harm by one firm in industry two prohibits such avoidance by another firm. In the case of negative externalities, potential locations for all firms are assumed finite. As discussed previously, if they were infinite no externality would exist. Because a negative externality is costly, and depending on the liability rule, entrants into one or the other industry will always wish to avoid the externality in order to maximize profit. The existence of an externality requires that the demand for sites by firms in both industries must be so great

⁵² In the case of the doctor and the confectioner, the appropriate social choice was not between doctoring and candy in the aggregate, but between doctoring or candy making or both at that location. Coase implies this but additional emphasis and specific modeling is necessary to show why.

that firms from the two industries are forced to locate "next" to each other.

Consider Figure IV-1 and the following scenario. There are S locations. At each location there is a site for a firm from both industry one and industry two. Assume firms in industry one fill their sites from the left, while firms in industry two enter from the right. If an externality producing firm and a receiving firm locate at " j ", a negative spillover is received. Location " j " will be occupied by a firm from both industries if and only if locations $1 \dots j-1$ contain industry one firms, and locations $j + 1 \dots S$ contain industry two firms. By the definition of a relevant negative spillover, the sum of the total profits of the externality related firms at location " j " is less than the sum of the total profits of an isolated firm in industry one and an isolated firm in industry two. Such overlapping (location by a firm at a site where it will either produce or receive a negative externality) will be avoided if possible.

Only when there is scarcity of locations will the profit maximizing behavior of the firms in the two industries allow a negative externality to exist. In this case, when a firm in industry two locates away from a firm in industry one, it avoids pollution but denies some other firm

1 ... j-1 j j+1 ... S

INDUSTRY ONE

...

INDUSTRY TWO

in industry two a pollution-free location.⁵³ The site specific nature of the externality makes it private.

Extended Pareto Efficiency Results From Model III

In this section the aggregate externality constraints for Model III are extended to include the possibility of isolated firms in both industries as discussed above. The number of locations in the economy is fixed at S . At each location there are two sites. However, only one firm of each industry may locate there. Even though the production functions of all firms in the same industry are identical, the externality received by isolated firms in industry two is zero. Also, the effect on social welfare of the externality produced by isolated firms in industry one is zero. The Pareto welfare function to be maximized is:⁵⁴

⁵³As previously noted, for expositional purposes the externality is assumed to be "one-on-one." This assumption could be modified so that many producing firms and many receiving firms could be affected, as long as the number was small enough to allow for bargaining. Clearly, if an infinite number of producing firms could be associated with an infinite number of receiving firms at each location there would be no negative externality because there would be no scarcity of alternative locations.

⁵⁴The terms ω_j , μ_i , ρ_i , ϕ , and σ_i are the Lagrangian multipliers. The resource not sold by each consumer has been relabeled as x_{cj} for notational clarity.

$$\begin{aligned}
\Omega = & \sum_j \omega_j (U_j^j(\cdot) - q_j) \\
& + \sum_{i=1}^4 \mu_i n_i f^i(\cdot) \\
& + \sum_{i=1}^2 \rho_i (q_i + q_{i+2} - \sum_j Q_{ij}) \\
& + \rho_3 (x - \sum_{i=1}^4 x_i - \sum_j x_{cj}) \\
& + \phi (S - \sum_{i=2}^4 n_i) + \sigma_1 (n_1 - n_2) + \sigma_2 (y_1 - y_2)
\end{aligned}$$

Four types of firms can be identified: Firm Ones and Twos produce and receive the externality, respectively; Firms Threes are isolated producers in industry one; Firm Fours are isolated producers in industry two. Thus

$\sum_{i=1}^4 n_i f^i(\cdot)$ is the production constraint for the economy.

Because a Firm One and Firm Two share a location, $n_1 = n_2$, and the location constraint for the economy can be expressed as $S - \sum_{i=2}^4 n_i$.

The Pareto welfare function, Ω , can be looked upon as a non-linear program where

$$n_2 + n_3 + n_4 \leq S.$$

According to the Kuhn-Tucker conditions either

$$(S - \sum_i n_i) = 0$$

or

$$\phi = 0,$$

where ϕ is the Lagrangian multiplier on the constraint.

The implication of this condition is clear when the partials of Ω with respect to each n_i are examined. Substituting $\{P_i, i = 1, 3\}$ for $\{p_i, i = 1, 3\}$ as in Chapter II we find:⁵⁵

$$1) \quad \partial\Omega/\partial n_1 = \partial\Omega/\partial n_2 =$$

$$\sum_{i=1}^2 (\mu_i f^i(\cdot) + P_i q_i - P_3 x_i) - \phi = 0$$

$$\partial\Omega/\partial n_3 = \mu_3 f^3(\cdot) + P_1 q_3 - P_3 x_3 - \phi = 0$$

$$\partial\Omega/\partial n_4 = \mu_4 f^4(\cdot) + P_2 q_4 - P_3 x_4 - \phi = 0$$

If ϕ is positive (locations are scarce) the value of ϕ can be interpreted as the Pareto efficiency shadow price on each location. The economic interpretation of this shadow price is that of a rent on each location.⁵⁶

The economic interpretation of the results of this model center on the term ϕ , the rent on each location. Each location has three alternative uses. Both goods can be produced, only good one can be produced, or only good two produced. Call these activities A, B, and C, respectively. Equation Set 1 shows that any or all of these activities may be Pareto efficient at the S available

⁵⁵As was the case in the previous models $\{p_i, i=1,3\}$ can ultimately be set equal to $\{P_i, i=1,3\}$ because all $\omega_j \lambda_j$ terms cancel. Also the marginal cost conditions for a Pareto maximum are the same as those for Model III, Chapter II, with the addition that $P_{i-2} = P_3 / (dq_i/dx_i)$, $i = 3, 4$.

⁵⁶The rent on a location is collected from both sites.

locations. In other words, only activity A may occur at all S locations, only activity B at all locations, or only activity C. Also, activity A may occur at some locations and activities B or C at the others, etc.

Equation Set 1 (disregarding the terms involving the implicit production functions) shows the rent equality condition for each location allowing for all possible alternative welfare maxima assuming the other first order conditions are satisfied. The model allows for isolated production or joint production of the two goods so long as the difference between total revenues and costs equals the rent, ϕ . If the difference between total revenues and costs for the alternative uses of a location all yield ϕ , all those activities occur at separate locations at the welfare maximum. If for any potential use of a location, the difference between revenues and costs is less than ϕ , that use efficiently occurs at no location. In other words, ϕ must be equal at each location and has the value of the difference between total revenues and costs at each location regardless of the activity that occurs there. The relative prices of good one and good two and the effect of the externality may rule out one or two of the three possible activities. We can think of an inefficient activity as one where the difference between total revenues and costs

are not enough to cover ϕ .⁵⁷ An efficient activity is one that generates enough revenues to cover the resource cost and the rent.

Intuitively, the rent is a measure of the social cost of not using a location in the most efficient manner. This result can be shown by means of the following scenario. If expansion of industry two causes an isolated producer of good one to become a joint producer, what is the "loss" to society? It is the difference between the value of the output of good one by an isolated producer and the value of the output of good one by a joint producer,

$$P_1q_3 - P_1q_1$$

plus the difference in the cost of resources expended,

$$P_3x_1 - P_3x_3$$

These two terms express the potential decrease in the production of Q_1 and the potential increase in cost.

The "gain" from such a move is the value of good two produced less the cost of good two,

$$P_2q_2 - P_3x_2$$

The move will increase society's welfare if

$$P_2q_2 - P_3x_2 > P_1q_3 - P_1q_1 - P_3x_1 + P_3x_3$$

which is to say,

⁵⁷Technically, if the difference between total revenues and costs is not equal to ϕ , the difference is made up by $\mu_i f^i(\cdot)$. This term is a measure of how close the activity comes to making the efficient solution. Because n_i is, then, equal to zero, the aggregate production-consumption identity is fulfilled.

$$2) \quad \sum_{i=1}^2 (P_i q_i - P_3 x_i) > P_1 q_3 - P_3 x_3$$

Hence, if the profitability of joint production (left hand side of Equation 2) is greater than independent production of good one (right hand side of Equation 2), it should be undertaken, but not if it is less.

These conditions show that when there are alternative uses of each location the marginal welfare effect of each use must be identical. Industry output adjustments can be thought of as occurring as in the scenario above to achieve a movement to the optimal solution. At the optimal solution isolated production of good one, isolated production of good two, joint production, or any combination of these three may occur at the S locations.

Summary

This chapter has developed an industry structure for the small number, private externality assuming that locational confinement is the delimiter of the external effects. This structure allows for isolated production or the avoidance of the externality. The Pareto efficiency conditions show that such isolation, indeed, may exist at the optimal solution. For a negative externality to exist at all there must be a scarcity of locations. If such scarcity exists, these uses of the locations that yields the maximum difference between revenues and costs are efficient. This difference can be considered a rent on each location.

For the Coase Theorem to hold it is necessary that the behavior of profit maximizing firms embody these extended Model III results. In the next chapter the behavior of profit maximizing firms and the industry adjustment based on such behavior are explored. At that time further consideration is given to the alternative, efficient equilibria introduced in the last section of this chapter.

CHAPTER V

THE COASE THEOREM

Introduction

The Coase Theorem holds that in the case of zero bargaining costs an externality will be efficiently internalized by the affected parties without government intervention. Implied by the theorem is that the rule of liability has no effect on the allocation of resources. The purpose of this chapter is to show how the competitive adjustment mechanism does achieve an efficient allocation of resources regardless of the liability rule.

From the last chapter, Pareto optimality requires a rent to exist on each location if a negative externality is experienced in the economy. This rent must be equal at all locations and absorb all of the profit regardless of the type of production carried out there. This chapter shows how the competitive adjustment process acting on these rents reassigns production at each location until efficiency obtains. Because a rent must exist for efficiency in the case of pollution, the liability rule is inconsequential.

In the Coasian case, all locations are homogeneous even though they may have different uses. The different uses allowed for are equivalent to the existence or not

of pollution at a location.⁵⁸ The Pareto conditions on rents indicate that the potential for avoidance of the externality at some locations is just as important as its proper internalization where it occurs.

The purpose of this chapter is to show how the competitive market mechanism fulfills the Pareto efficiency conditions. In order to do this, the actions of a profit maximizing firm that produces both good one and good two are shown to fulfill the Pareto conditions where pollution occurs. At the same time, the analysis of the joint profit maximizing firm is developed in a way that can be used to compare the relative profitability of isolated and joint production. Next, a distinction between rent and economic profit is made in order to describe the competitive adjustment process. Rent is the payment to the scarce factor of production locations. Profit is the payment for the short run misallocation of resources. The process of industry expansion and contraction is first developed in the case of no external effects. After the definitions of rent and profit are explored, the case of a negative externality is presented.

⁵⁸Thus the simplifying assumption that two firms of one industry can not produce at one location is made. The model only allows for isolated production of either good, which is a situation of no pollution, or joint production wherein pollution occurs.

Joint Profit Maximization

Assume one firm maximizes the profit of simultaneously producing both good one and good two. The constrained profit function is:

$$\pi = \sum_{i=1}^2 \{P_i q_i - P_3 x_i + \phi_i f^i(\cdot)\} + \psi(y_1 - y_2)$$

The last constraint can be substituted into the production function $f^2(\cdot)$; y_1 and y_2 can be relabeled as y . The first order conditions can be expressed as:⁵⁹

$$1) \quad P_1 = P_3 / (dq_1/dx_1) - P_2 (\partial q_2 / \partial y) (dy/dq_1)$$

$$2) \quad P_2 = P_3 / (dq_2/dx_2)$$

These expressions are identical to the marginal cost requirements for Pareto optimality from Model III where the externality exists.

Equation 1 can be rewritten as:

$$1a) \quad P_1 - P_3 / (dq_1/dx_1) = -P_2 (\partial q_2 / \partial y) (dy/dq_1)$$

The left hand side of Equation 1a is a typical price-minus-marginal-cost expression for good one and is the change in profits due to a change in good one without considering the externality. The right hand side of Equation 1a is the effect on profits due to the effect on q_2 .

⁵⁹ Important in the derivation of Equation 1 is the fact that y and q_1 are joint products. Hence, $-f'_x = f'_q dq_1/dx_1 + f'_y dy/dx_1$.

The two sides of Equation 1a can be integrated to yield total profit expressions.⁶⁰ Thus, $\int \{P_1 - P_3/(dq_1/dx_1)\} dq_1 = \int P_1 dq_1 - \int \{P_3/(dq_1/dx_1)\} dq_1 = P_1 q_1 - C(q_1)$, where $C(q_1)$ is the total cost of producing q_1 from x_1 . The profit resulting from the production of good one can be defined as $\pi^1 = P_1 q_1 - C(q_1)$, where q_1 is determined from the solution of Equations 1 and 2. Likewise, the profit resulting from the production of good two is $\pi^2 = - \int \{P_2(\partial q_2/\partial y)(dy/dq_1)\} dq_1 = k - D(q_1, q_2)q_1$, where $D(q_1, q_2)q_1$ is the value of the damage imposed on the production of good two by the production of good one, and k is the constant of integration.⁶¹ The values of $D(q_1, q_2)$ and k are dependent on the level of q_2 determined from the solution of Equation 2. If $q_1 = 0$, k is the level of profit made by the isolated production of good two. The shape of π^1 is determined by the relationship of x_1 to q_1 , which, by assumption, is characterized by increasing and then decreasing returns to x_1 . The shape of π^2 is determined by the relationship of y to q_1 and to q_2 . By assumption, the negative externality's effect increases at an increasing rate. For simplicity, we assume that $y = q_1$.

In order to relate these total profit functions to each other and to the marginal profit functions from which

⁶⁰This approach is used in Gifford (74) and Maloney (77).

⁶¹By assumption of the nature of the production function there is no constant of integration in the construction of π^1 .

they are derived, it is enlightening to show the equality from Equation 1a as a tangency of π^1 and π^2 . To accomplish this we simply invert π^1 and measure the level of π^1 in the opposite direction of π^2 along the vertical axis. By bringing this inverted π^1 curve down onto the π^2 curve, the tangency results. Such a graph is shown in Figure V-1. Point U, Panel A, is the appropriate tangency.

From this graph not only do we see the level of joint profits, but also the level of profit resulting from isolated production of each good. In Figure V-1, Panel A, the distance O_1O_2 is the maximum profit from producing both good one and good two; the distance O_2R_4 is the maximum profit from producing only good two; the distance O_1R_3 is the maximum profit from producing only good one.

Figure V-2 shows the decline in the profit levels as price falls: the dashed-line curves show the post price-decline profit levels. In other words, as P_1 decreases, the π^1 function is compressed in a horizontal fashion and rotates upward about point O_1 . Profit falls, as does the profit maximizing quantity of good one if produced in isolation. As P_2 declines, π^2 simply drops down.⁶² After such a shift in either curve, π^1 must be brought back down onto π^2 until a tangency similar to point U, Figure V-1, Panel A, again occurs. Hence, after a price change, the

⁶²The vertical distance between the old and new curves will be everywhere equal if $\partial^2 q_2 / \partial y \partial q_2 = 0$.

FIGURE V-1

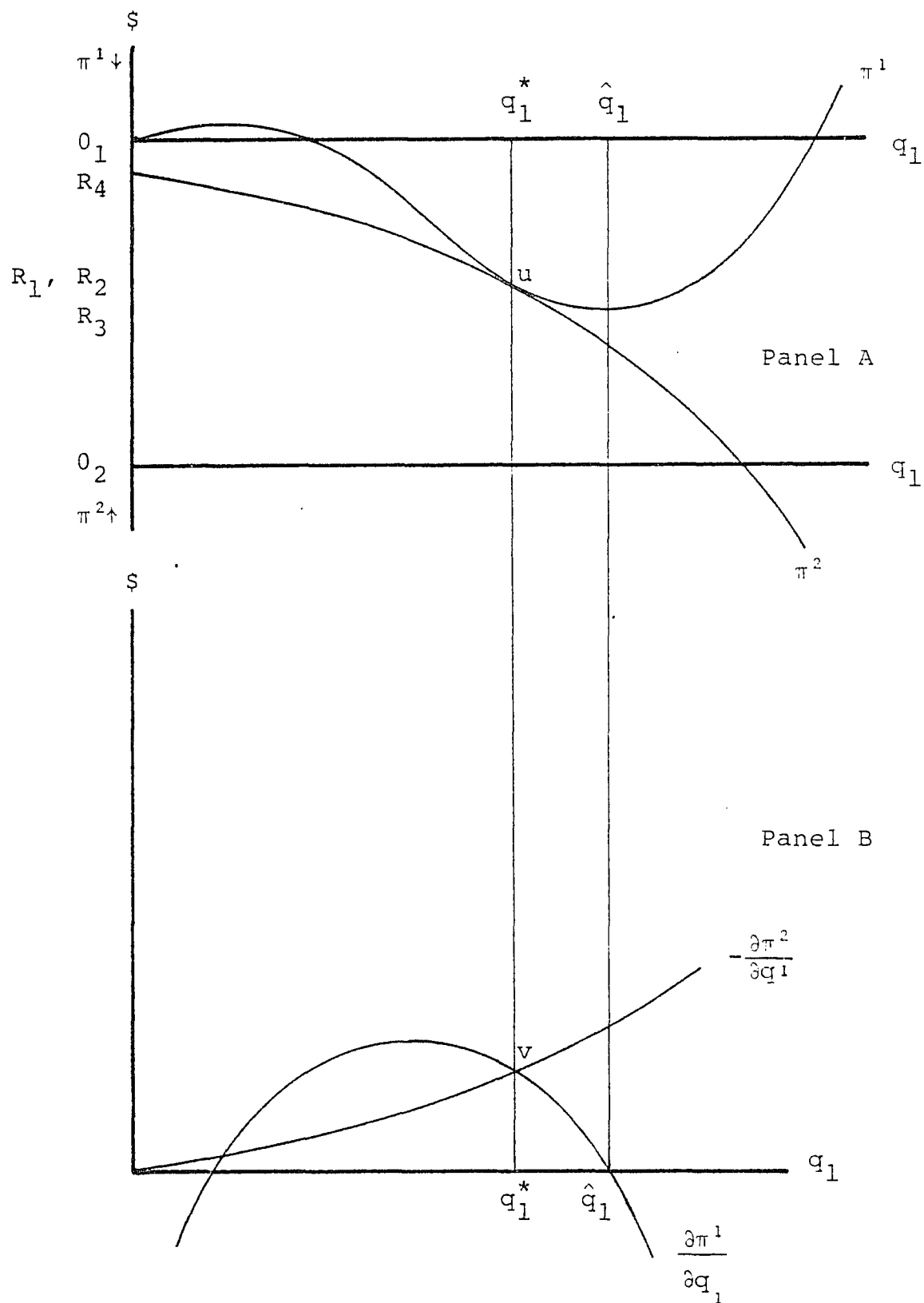
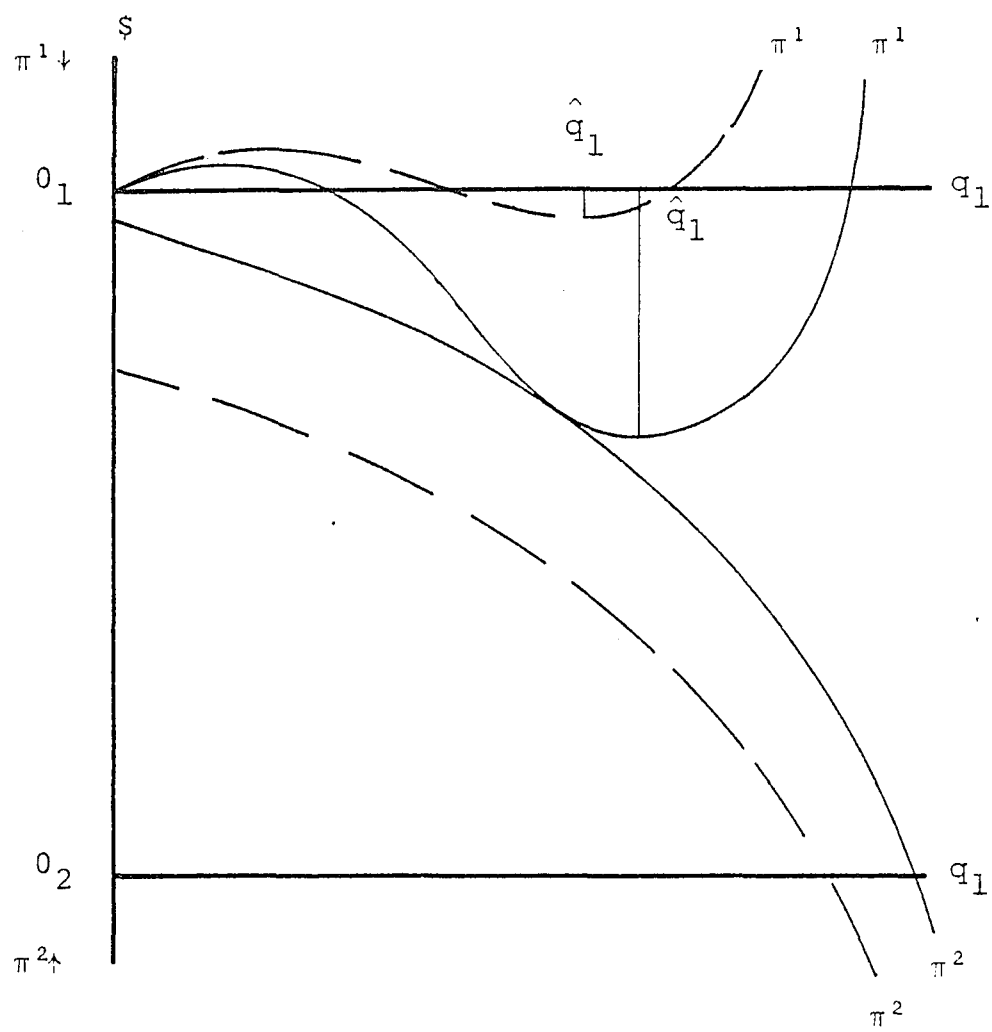


FIGURE V-2



relationship of the distances 0_10_2 , 0_2R_4 , and 0_1R_3 changes.⁶³ The relative profitability of these three activities forms the basis of the industry adjustment mechanism in the case of externalities.

Industry Adjustment: No Externality

As in the Pareto welfare model of the last chapter, consider an economy having only S locations at which the firms of the two industries may produce. In the case of no externality, assume only one firm can produce at each location. Again assume that there are no costs associated with relocation of firms. Also, the S locations in the economy require no maintenance and they are homogeneous. While locations and the input x are both resources for the economy as a whole, they are not substitutes for the firm. One firm only can operate one site.⁶⁴

In order to begin the industry adjustment, allow industry one to expand its output by expanding the number of firms until the excess profit of each firm is zero. Firms in industry one occupy n_1^0 locations. Now allow firms in industry two to begin production.

⁶³ Note that second order conditions can be investigated by examining the relationship $0_2R_4 \leq 0_10_2 \leq 0_1R_3$. $0_1R_3 \leq 0_10_2 \leq 0_2R_4$ must be true for the second order conditions of joint profit maximization to be met.

⁶⁴ In other words, the function $f^i(\cdot)$ is applicable to one site only. Also, for the economy, output is a linearly homogeneous function of the two resources, sites and x .

If the profit from the production of good two falls to zero before all S sites are occupied, locations are not scarce and rent is zero. If all sites are occupied, i.e., $n_2 = S - n_1^0$, and if the profit of the firms in industry two is positive, locations are scarce and a rent will arise. Figure V-3 depicts the allocation of the sites at this point. The profit of a firm in industry two (π^2) is positive, the profit of a firm in industry one (π^1) is zero, and rent at all locations is zero.

A new firm will enter industry two because of the excess profits. In order to enter, the firm must pay one of the landlords of the n_1^0 sites some portion of the π^2 . Because the rent is currently zero, this payment, ε , may be arbitrarily small.

When the industry two firm drives the industry one firm out of business, it causes a reduction in the output in industry one. Standard theory tells us the price of good one and, hence, the net revenue (revenue minus the cost of the resource x)⁶⁵ of the firms in industry one rises. Under the normal assumptions of competition, the actions of one firm have an imperceptible effect on price. But as more firms enter industry two because of the excess profits, the result is observable.

Figure V-4 shows the reallocation of sites that results in a change in the net revenue levels. The number

⁶⁵Net revenue is identical to profit only if the rent on the location is zero.

FIGURE V-3

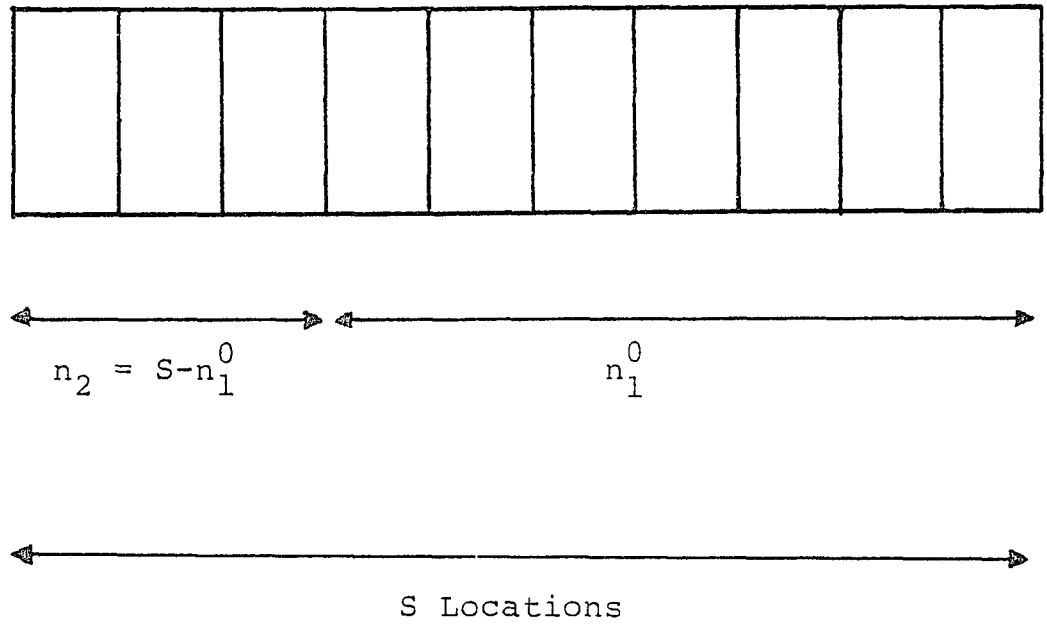
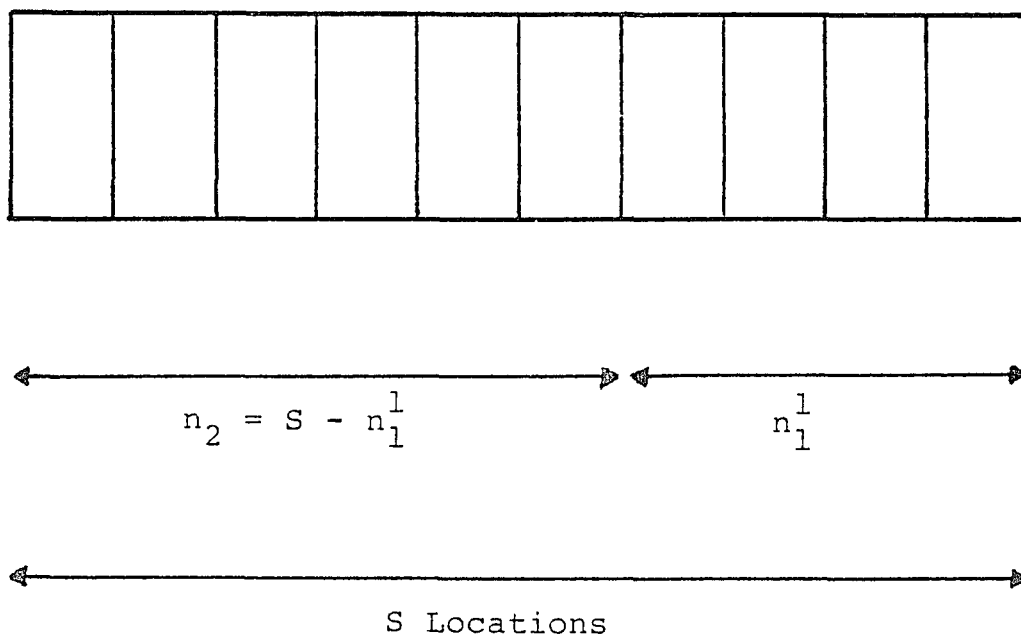


FIGURE V-4



of sites occupied by firms in industry one has fallen from n_1^0 to n_1^1 . The net revenue of the firms in industry one grows because of the reduction in output resulting from the displacement of firms in industry one. However, this net revenue will not be kept by the industry one firms. Instead it is paid to the landlords of the sites at which they produce. Moreover, the rent paid by a firm in industry two will also equal this amount.

The net revenue of the firm in industry one is in this case the opportunity cost of all locations. Competition among the landlords will drive the rent to this level. A firm in industry two can always relocate to a site occupied by a firm in industry one by offering to pay ϵ more than this amount. A landlord can always offer a site for ϵ less and induce a different firm to move in. Competition will force ϵ to approach zero and the rent at all sites to approach the net revenue of the least profitable firm.

As this process unfolds, the distinction between rent and profit develops. Rent is the payment for scarce locations. Its value is the lowest net revenue of all firms producing. The value of the rent is determined by relocating the existing firms in the two industries. Assuming that the industry output levels remain constant, competition for the scarce locations determines the rent. Firms will continue to relocate so long as rents are not equal. Excess profit can then be computed as the difference

between net revenue and rent. New firms will continue to enter the market so long as excess profits are positive.

The terms R^1 and R^2 can be defined as net revenue for firms in industry one and two, respectively. As the industry adjustment occurs, the rent, ϕ , is equal to the $\min (R^1, R^2)$. Profit can then be defined as $\pi^1 = R^1 - \phi$ and $\pi^2 = R^2 - \phi$.

As in the standard competitive model, output of the industry with positive profit expands. In the case of scarce locations, the expansion of the industry experiencing positive profit causes the contraction of the other industry as one location changes from the production of one good to the other. The joint industry equilibrium occurs when excess profits are zero, i.e., $\pi^1 = \pi^2 = 0$. At this point the rent equals the net revenue of the firms in both industries, and the net revenue of the firms at all locations is equal.

The importance of the distinction between rent and profit is simply that profits are caused by short run resources misallocation. They mirror the forces at work to change the output of the two industries. Those forces cause an expansion of the industry experiencing positive profits. Rent, on the other hand, reflects the scarcity of sites and measures the opportunity cost to each firm of a location given the current allocation of resources. Rent is the maximum payment attainable by the landlord, resulting from the exchange of sites by two firms. The

computation of rent assumes that the output levels of the two industries remain constant. Obviously, these processes may be at work simultaneously. The distinction is drawn in order to clearly identify the equilibrating mechanism.

Industry Adjustment: Negative Externality

Now let us assume that the production of both goods may occur at one location but that in so doing a negative externality occurs. This pollution causes the cost of producing good two to increase. There are still S locations and either good one, good two, or both can be produced at each. Note, however, that two firms of the same industry cannot locate at one site.

Using the same scenario as in the non-pollution case, allow the number of firms in industry one to initially expand until the profit from the production of good one is zero. Then allow firms to enter industry two until all S locations are filled. Scarcity of locations is evidenced by positive profits made by the firms in industry two when all locations are filled. At this point rents are still zero.

The relative profitability of the different potential activities at each site can be examined by means of the graphical analysis developed earlier in this chapter. The net revenue made by the isolated producers of good two is termed R^4 ; the net revenue made by the isolated producers of good one is termed R^3 ; $R^1 + R^2$ is the net revenue from the joint profit maximizing production of both goods.

Figure V-5 shows the situation where $R^3 = 0$, $R^4 > 0$, and $R^1 + R^2 > 0$ even though joint production of the two goods does not occur. Recall that positive net revenue from the production of good one is measured downward from point 0_1 ; positive net revenue from the production of good two is measured upward from point 0_2 .

Returning to our scenario, as drawn, the profit⁶⁶ from isolated good two production, R^4 , is the distance 0_2R_4 . Because this is greater than the net revenue from either isolated good one production, 0_1R_3 , or joint production, 0_10_2 , a firm will enter industry two and drive out a firm from industry one. This occurs by means of the new industry two firm paying an arbitrarily small amount of R^4 to the landlord of an existing isolated good one producer. At this point a rent, ε , exists albeit arbitrarily small. All firms will be forced to pay the rent because of the scarcity of locations and competition for them.

As more firms enter industry two as isolated producers, the net revenue functions of all firms shift. The net revenue from the production of good one increases and that from the production of good two falls. Assume that the magnitude of these shifts occurs as depicted in Figure V-6. Also assume that isolated good one production

⁶⁶Remember profit is equal to net revenue only if rent is zero.

FIGURE V-5

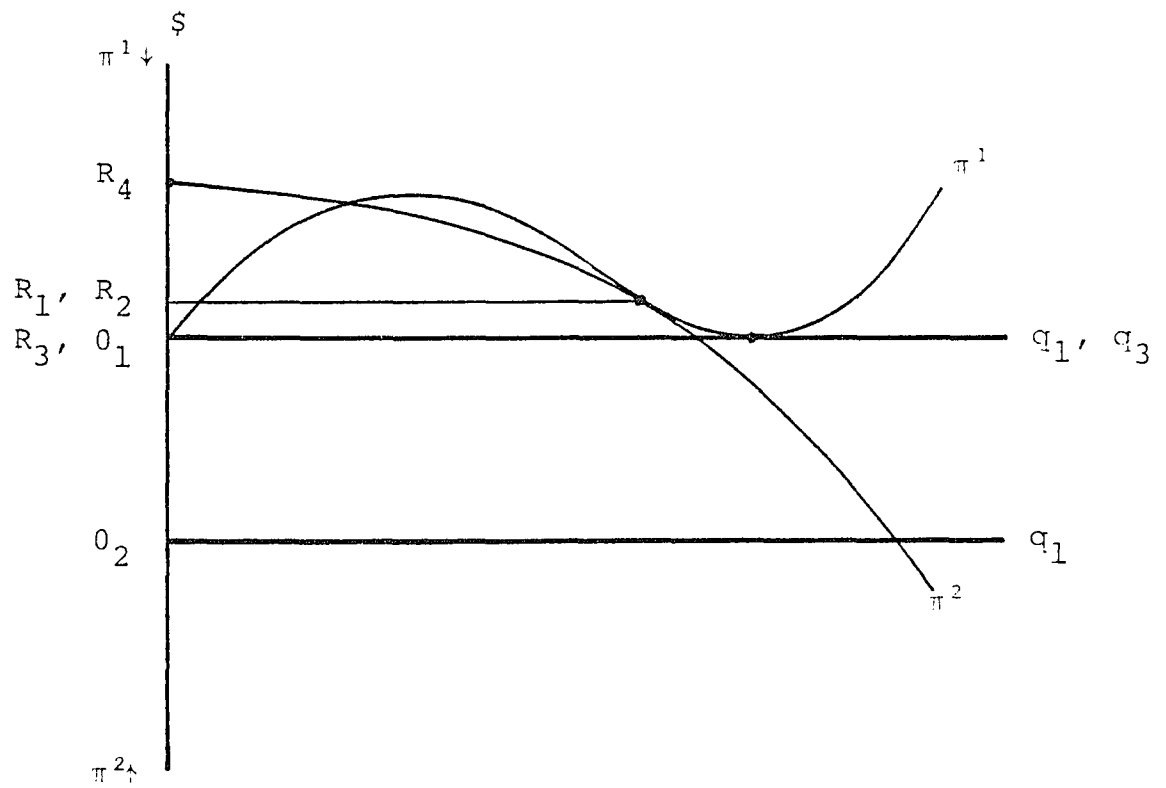
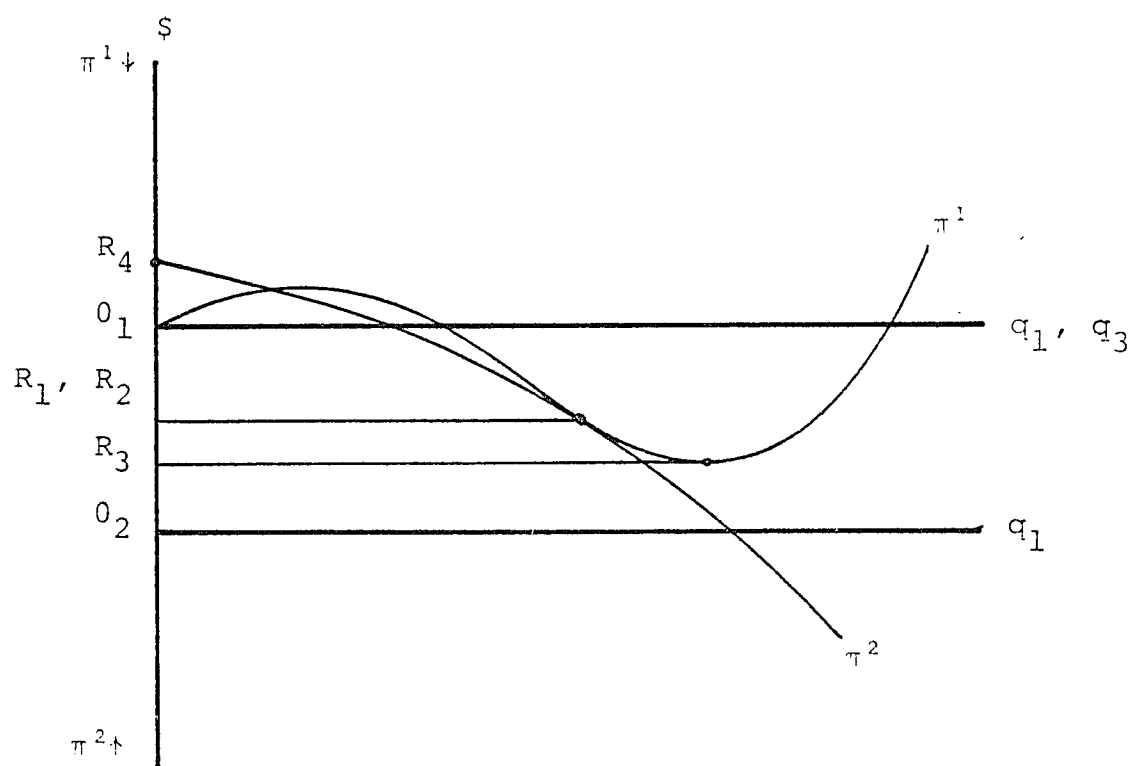


FIGURE V-6



still exists at some locations. Because the net revenue of isolated good two production still exceeds both joint and isolated good one production, firms continue to enter industry two as isolated producers, driving out firms from industry one.

Applying the definitions of profit and rent from the last section we find that the rent is R^3 , the net revenue from the isolated production of good one. Because isolated good one production still exists and yields the lowest net revenue it is the opportunity cost of all locations. If a landlord attempts to extract more than R^3 from a producer of good two, the firm merely exchanges locations with a good one producer by offering its landlord R^3 plus ϵ . Competition drives ϵ to zero. The rent $\phi = R^3 = \min (R^3, R^4)$.⁶⁷

The profit levels of the various potential activities are $\pi^1 + \pi^2 = R^1 + R^2 - \phi$, $\pi^3 = R^3 - \phi$, and $\pi^4 = R^4 - \phi$, where $\pi^4 > \pi^1 + \pi^2 > \pi^3$. The adjustment rule is that the activity with the highest profit drives out the activity with the lowest. Hence, firms continue to enter industry two as isolated producers, thus driving out firms from industry one.

Following this scenario to one of many possible outcomes, assume that as firms enter industry two, R^4 falls

⁶⁷ $R^1 + R^2$ is not included in the $\min (\cdot)$ statement because no location houses such production.

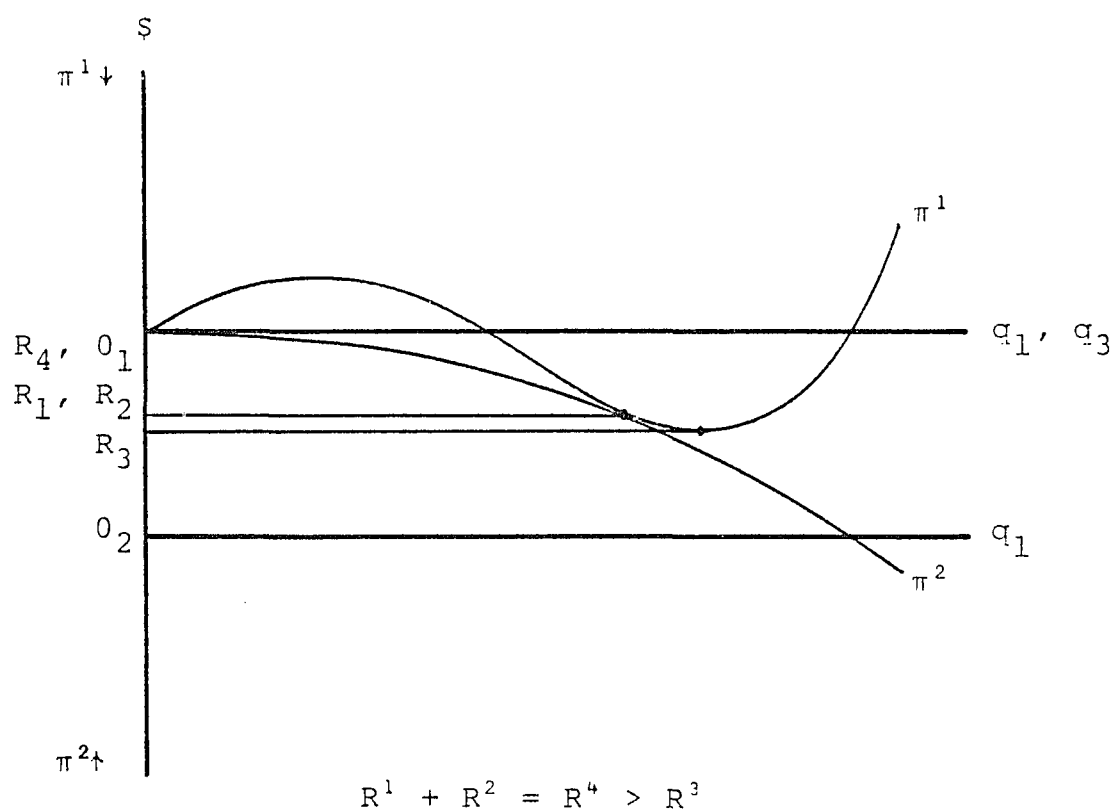
into equality with $R^1 + R^2$. This is shown in Figure V-7. Because at this point isolated good two production has the same profitability as joint production, the firms currently producing good one in isolation may or may not leave industry one. However, they will not continue isolated production. Because the net revenue of isolated good one production remains below the other potential activities it is eliminated from all sites; some sites will house joint production. Thus, the opportunity cost of a location becomes $\min(R^1 + R^2, R^4)$. Because they are equal, as assumed by Figure V-7, the rent wipes out all the profit and the industries are in equilibrium. $\pi^1 + \pi^2 = \pi^3 = \pi^4 = 0$.⁶⁸

There are six other possible equilibria, all shown and labeled in Figures V-8--V-13. In all cases excess profits are zero and the rent absorbs all of the net revenue yielded by production at each location. It is important to note that these equilibria do not depend on the initial position of the industry adjustment process, but depend on the relative demands and costs including the effect of the externality. From any disequilibrium, the same equilibrium will obtain, determined only by the relative costs and demands in the two industries.

The industry adjustment process in the case of pollution is the same as in its absence. The activity with

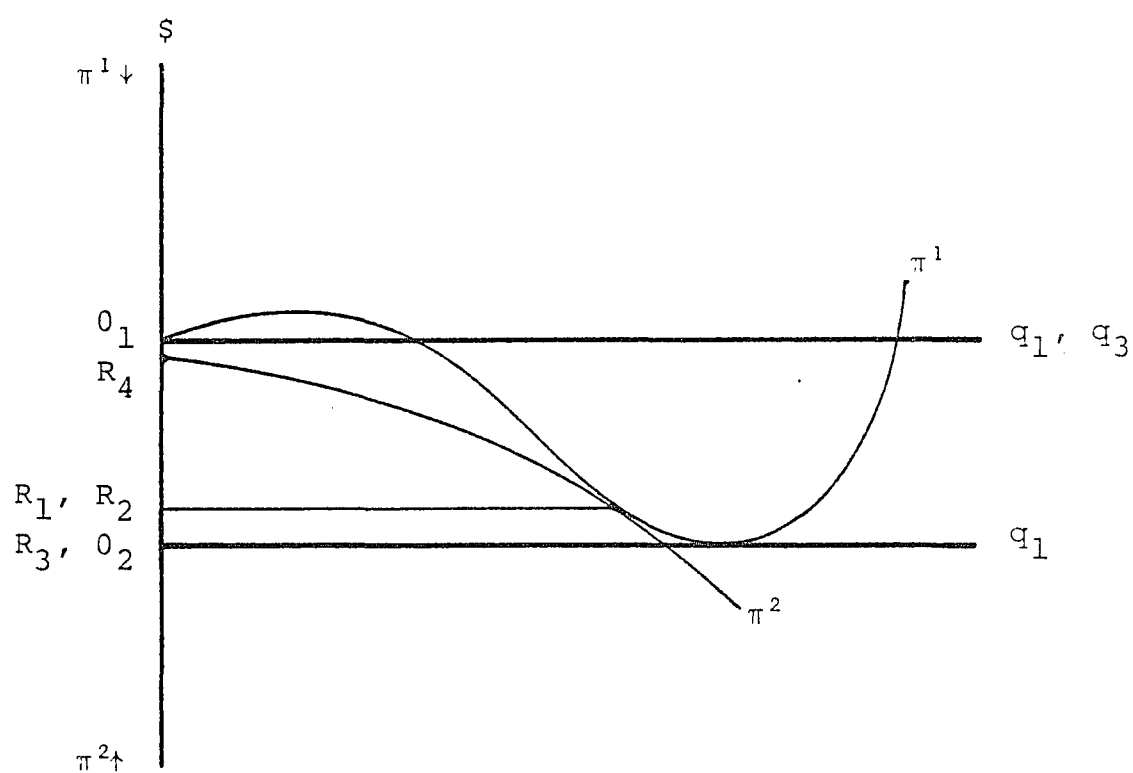
⁶⁸The excess profit of an activity which is pursued at no location is definitionally zero.

FIGURE V-7



Isolated good one production
is eliminated.

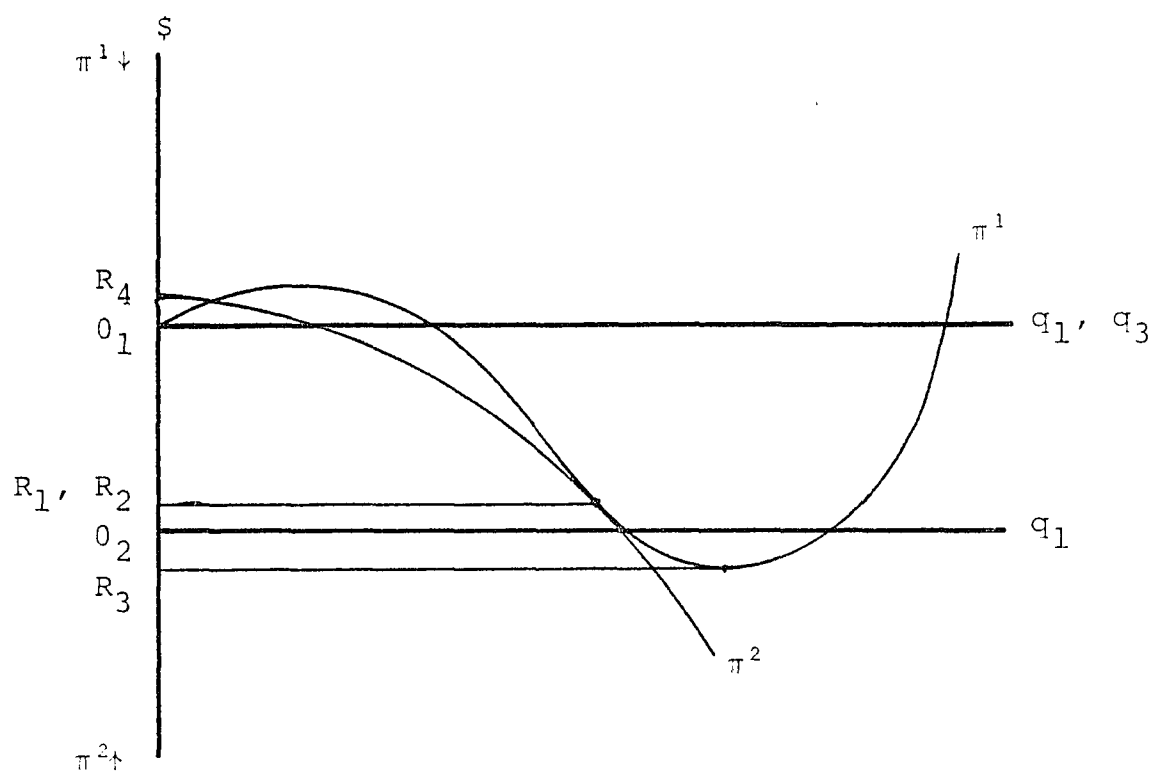
FIGURE V-8



$$R^1 + R^2 = R^3 > R^4$$

Isolated good two production
is eliminated.

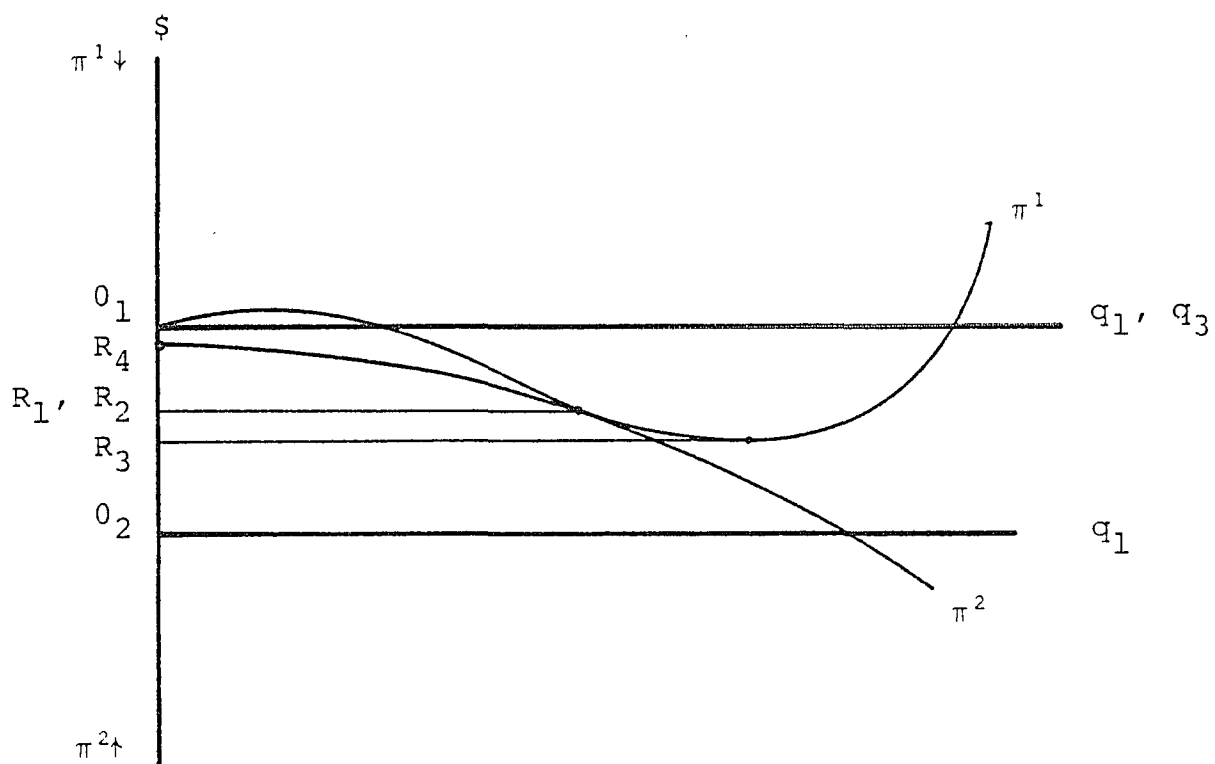
FIGURE V-9



$$R^3 = R^4 > R^1 + R^2$$

Joint production is eliminated.

FIGURE V-10

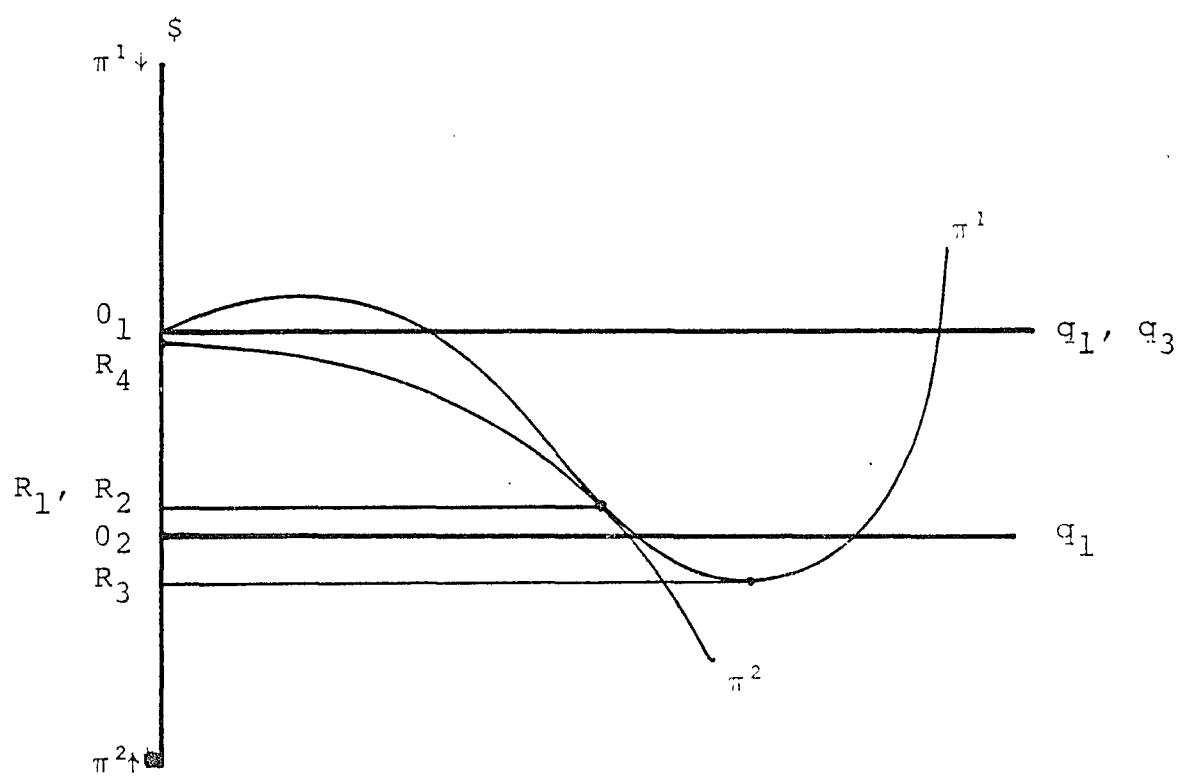


$$R^1 + R^2 > R^3$$

$$R^1 + R^2 > R^4$$

Only joint production occurs.

FIGURE V-11

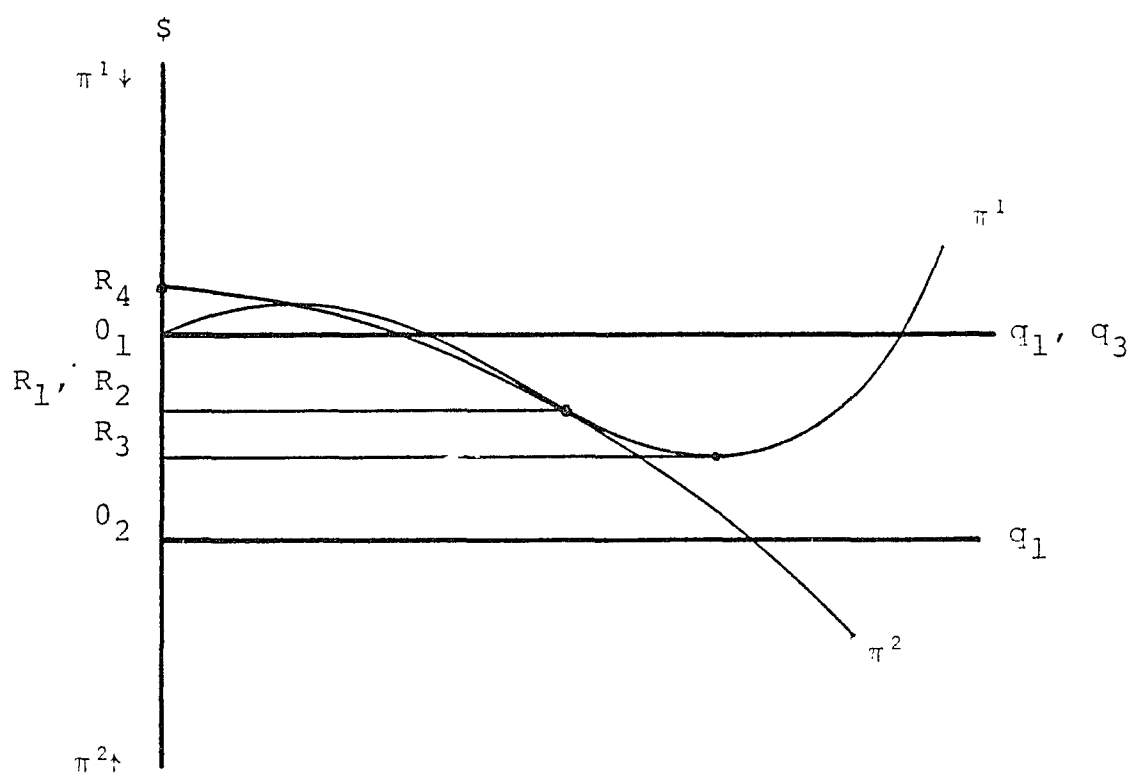


$$R^3 > R^1 + R^2$$

$$R^3 > R^4$$

Only good one production occurs.

FIGURE V-12

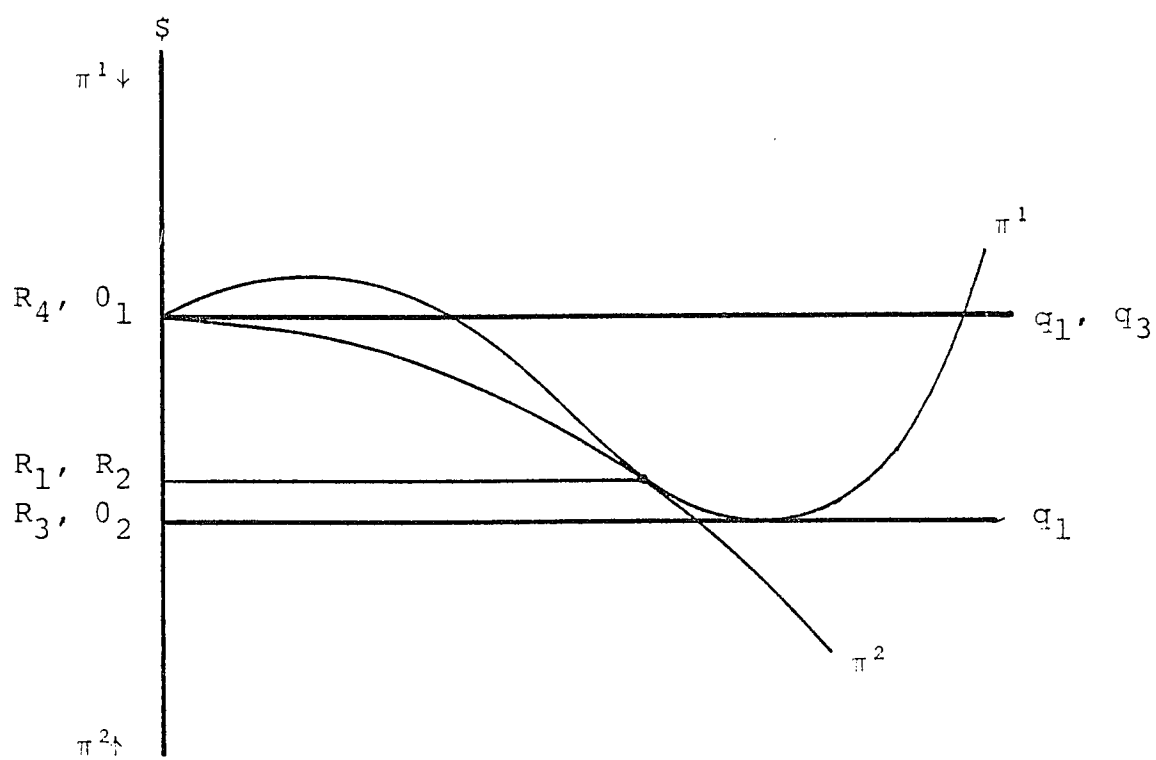


$$R^4 > R^1 + R^2$$

$$R^4 > R^3$$

Only good two production occurs.

FIGURE V-13



$$R^1 + R^2 = R^3 = R^4$$

Both isolated good one and good two as well as joint production occurs.

the highest profit drives out the activity with the lowest, and all resources are sold at their opportunity cost. In the case of scarce locations, the opportunity cost of a site is the lowest net revenue attained by production at any site.

Conclusions

The implications of these results in terms of the Coase Theorem are:

1) The equilibrium of the competitive market mechanism in the Coasian case exhibits the optimality conditions derived in the previous chapter. The assumptions made about the behavior of the market participants are that producers profit maximize and that landlords rent maximize. Profit maximization ensures the marginal cost efficiency conditions. Competition and rent maximization cause production at each location to afford the same rent and the rent absorbs all of the net revenue. Thereby, the industry size conditions for Pareto optimality are fulfilled. Thus, the Coase Theorem holds.

2) In order to achieve optimality and because of competition, pollution may or may not exist in the economy or at any particular site. The allocation of resources in such a way that no externality exists is as important in achieving efficiency as is its correct internalization where it does occur. At the locations where the externality is optimally avoided, it is interesting to note

that the net revenue or quasi-rent does not exist to allow pollution to exist. The competitive mechanism assures this.

3) Liability does not matter. If pollution exists so must a rent. Rent maximization by the landlord precludes the effect of the liability rule. Even if firms in industry one are not sanctioned by law for their pollution, the number of polluting firms will not expand past the efficient level. New firms will not enter industry one and cause pollution unless they can make the net revenues necessary to pay the rent afforded by isolated good two production. If efficiency requires isolated good two production, the competitive mechanism will not afford the net revenue sufficient to drive out the isolated producers. This is true even though the firms in industry one may legally pollute.

4) If at a particular location more than one landlord exists or if no landlord exists, the results are not mitigated. If no landlord exists, the firms in the industry with the pollution property right will effectively become the landlords. If more than one landlord exists, bargaining among them will produce the efficient solution.⁶⁹

⁶⁹This assumes that bargaining among the landlords can be carried out with zero transactions costs. If so, the maximum rent at any one location is the efficient rent. However, there is a problem with extortion in this case as will be discussed in the next chapter.

Summary

This chapter has presented a proof of the Coase Theorem. It has been demonstrated that profit maximization, rent maximization and competition for scarce locations will result in the fulfillment of the Pareto conditions for a Type III externality. The marginal cost conditions are satisfied by joint profit maximization where the existence of the externality is called for and by simple profit maximization where it is not. Rent maximization ensures that the externality exists at the efficient number of locations. The distinction between rent and excess profit points out how the competitive mechanism adjusts the output of the two industries and generates the net revenue necessary to create or stop pollution where required for efficiency. As held by Coase, the definition of property rights has no effect on the solution.

CHAPTER VI

IMPLICATIONS AND EXTENSIONS OF THE RESULTS

Introduction

The previous chapters have developed the necessary conditions for Pareto welfare maximization in three different models. These models are specified in a way consistent with both the Pigovian and Coasian concepts of the externality problem. From an examination of these three models the Pigovian and Coasian traditions are reconciled and the Coase Theorem proven.

The conclusions reached in this paper follow from the specification of the aggregate externality constraint used in the three models. These specifications were developed by appealing to an outline of externality problems that separates the publicness or privateness of reception from the question of bargaining costs.

Bargaining costs have been used in the past to distinguish the Pigovian and Coasian cases. This has caused confusion in both analysis and policy implications. Baumol (72) points out that both Buchanan and Coase, in letters, express confusion and concern over who should pay for pollution in the laundry-factory example. The possibilities run the gamut from all should pay to either the producer or receiver of the externality should receive compensation.

At the same time that results of the small number case have cast doubt on Pigovian policy, the question of who should pay has been used to attack the small number case itself. If, as the proponents of the Coase Theorem claim, the liability rule is inconsequential, the question of who should pay does not affect industry adjustment. However, other writers have claimed that industry adjustment and equilibria are, in fact, affected by the liability rule. The liability rule is not symmetric and, hence, the Coase Theorem does not hold.

By addressing the public/private reception question separately, we are able to consistently identify the appropriate policy and thereby reconcile these opposing views. This chapter reviews the reconciliation of the Pigovian and Coasian traditions and the proof of the Coase Theorem presented in the preceeding chapters. Extensions and ramifications of the Coase Theorem are then studied.

Review of the Findings

The outline of externality problems suggested by considering both public/private reception and large/small numbers is fourfold. Type I is large number, public reception; Type II is large number, private reception; Type III is small number, private reception; and Type IV is small number, public reception.⁷⁰ The interesting thing

⁷⁰Type IV is ignored here.

about this scheme, however, is the notion of privateness. The key contribution of this research is that the cause of private reception can be the scarcity of locations in the reception area. In fact, in Type III externalities this is assumed to always be the case.

Public reception means that the amount of the externality received by one firm in no way diminishes the amount available to others. On the other hand, private reception is a situation where the amount of the externality available is somehow constrained. This can occur either by a reduction in the quantity of externality due to reception by one firm or by a reduction in the locations available for the reception of externality due to the existence of a receiving firm.

Who Should Pay?

The public reception case is addressed by Model I. The results are clearly that the producer of the externality should pay a price equal to the harm caused by the externality. This payment is recognized in both the average cost and the marginal cost requirements for each firm. The receiving firm in the public case should not be taxed or compensated. Again, this result is shown by the absence of explicit externality expressions in either the marginal or average cost conditions for the receiving firm. This result is intuitively pleasing. In the public reception case, no scarcity of the externality

exists.⁷¹ Thus, the price of the externality faced by the receiving firm should be zero.

The private reception case is developed in both Models II and III. Model II examines a situation where the actual aggregate quantity of the externality is reduced by the amount received by one firm. The welfare maximizing conditions in the case of a positive externality are identical to those of a normal input produced as the joint product of an output. The producing firm is compensated for the externality and the receiving firm pays for the portion of the externality it receives.⁷² If the externality is negative the reverse holds: producers pay and receivers are compensated.

In general, a problem of defining and protecting the property rights is the causal factor of such a Type II externality, either positive or negative. For instance, we may have a positive externality problem because the spillover is a "common access" resource to the receivers.⁷³ Government action is called for. The form of this government action could be a Pigovian tax where the tax rate is

⁷¹ Scarcity of the externality means ability to avoid the effects if negative.

⁷² An example in a normal market is where the by-products of cracking gasoline are sold to firms that use them as inputs.

⁷³ The case of shrimp growing up in marsh lands was found by Maloney et. al. (77) to be such an externality. The problem of the commons occurs in the ocean where property rights are hard to define. The externality is that oystering, clamming, and crabbing affect the number and size of shrimp leaving the estuary.

$P_2(\partial q_2/\partial y_2)$.⁷⁴ This rate is levied per unit of externality. Externality producers should be charged at this rate and externality receivers compensated at this rate for negative spillovers. The direction of the payment changes with the sign of the externality.

Alternatively, the externality may be privately received because of the scarcity of locations in the reception area. This situation is examined in Model III. Model III was extended to include the possibility of isolated production. The results are simply that the firms involved in the externality at any location must act like joint profit maximizers.

It is the extended Model III that gives the welfare conditions pertinent to the Coase Theorem. If firms cannot avoid the negative externality, locations must be scarce. Hence, a rent exists. Assuming zero transactions costs the rent maximizing behavior of the landlords yields optimality. Optimality requires that the rents be equal across all locations.⁷⁵ By explicitly noting that the cause of the externality is the scarcity of locations, rent maximization can be shown to produce a Pareto welfare maximum. Thus the Coase Theorem is demonstrated.

Traditionally, the Coase Theorem has implied either party can be made to pay for the externality. More

⁷⁴See Model II, Table III-1.

⁷⁵Joint profit maximization ensures that the rents are maximized at each location.

precisely, Chapters III and IV show that both parties should be made to pay. In Type III externalities, where the Coase Theorem is directly applicable, both parties are made to pay in terms of the rent collected by the landlords. If autonomous firms are involved in the externality, the liability rule is inconsequential precisely because both parties pay rent equal to the exact amount of their share of the maximum joint profits.

If we apply Model III to the case of Type II externalities where the externality is private due to scarce locations, the result is also that all parties should pay. This is a large number case because the number of producers or receivers at each location prohibits bargaining. The Pareto requirements are simply that all the firms at each location joint profit maximize. A straightforward government policy is to act as the auctioneer of environmental purity. The polluting firms pay for pollution rights; the externality receiving firms pay for purity. Maximizing government revenues, maximizes welfare. Even though within a single pollution area the externality is a public good subject to the free rider problem, government can force all receiving parties to pay. The technique of the taxing procedure requires further study outside of this investigation. The point here is that theoretically both producer and receiver should pay.

Summary

We can summarize these results in such a way as to delineate the externality situations relevant to the Pigovian tradition and those relevant to the Coase Theorem.

- A) Type I externalities are Pigovian cases. A simple, unilateral tax or subsidy like that proposed by Baumol is appropriate.
- B) Type III externalities are pure Coasian cases. No government policy at all is required to achieve efficiency.
- C) Type II externalities fall under both the policy prescriptions of Pigou and Coase.
 - i) If the externality is private because the available quantity is reduced by the reception of one firm, a bilateral tax and subsidy scheme is called for. This is the type of Pigovian tax discussed by Meade and Gould.
 - ii) If the externality is private because of the scarcity of locations in the reception area, the rent maximizing results of the pure Coasian case must be implemented by government.

Thus are the Pigovian and Coasian traditions reconciled.

Ramifications of the Coase Theorem

Probably the most obvious criticism of the Coase Theorem is that zero transactions costs are assumed. Many writers, notably Baumol (72), Daly (74), and Coase (60), have argued that transactions costs will significantly diminish the applications of the Coase Theorem in real world problems.

The essence of the controversy is whether the Coase Theorem can legitimately be applied to problems of pollution control in the typical situation involving large numbers of affected

parties, not all of whom have access to capital markets.⁷⁶

There are a number of issues involved here. First, when does the largeness of numbers create insurmountable transactions costs? Second, when is the externality publicly received so that the Coase Theorem becomes analytically inappropriate in spite of transactions costs? Finally, what is the extension of Coase's arguments to consumers involved in externality problems?

These questions cannot be completely addressed here, mainly because the analysis used in this research is not formulated to answer them. However, our analysis does give some insight into these problems.

Public Reception in Actual Pollution Problems

Inasmuch as the pollution is public, the Coase Theorem is never applicable either in terms of the necessity or form of government action. However, by the analysis presented in this paper the actual existence of the Type I externality problem is very much in doubt. It appears that purely publicly received externalities are unlikely because of the general scarcity of locations everywhere. This fact implies that the simple Pigovian tax is never applicable. The appropriate government policy, then, becomes one of taxing all parties of the locationally specific externality

⁷⁶Fisher and Peterson (76), page 4.

or doing nothing. The Coase Theorem offers both alternatives.

This result is mitigated somewhat by the vagaries of nature. Pollution may affect one area or another in a very random fashion. However, the appropriate tax asks receivers to pay for reducing the expected damage of pollution, and then charges the polluters that same price at the equilibrium.

Bargaining Costs

The problem of bargaining costs addressed in the literature centers on two points. First, if bargaining costs are too high to allow private internalization, the cost of information necessary to implement the appropriate government policy is also prohibitive. The appropriate government policy can never be implemented and, hence, standards are the most efficient means of achieving a welfare maximum. Second, if government taxing policy is used, the Buchanan-Stubblebine problem appears. Private internalization, if possible, will move the parties away from the welfare maximum.

Both of these arguments are based on the confusion between public and private reception. As we have pointed out, if the externality is private by the fact of scarce locations, two conclusions result. Both parties should pay and the payment is made from rents on locations.

The fact that the tax in a large number case should be levied on both parties instead of one, means that

government can gain information about the severity of the pollution by the tax revenues obtained from the receivers. In many cases it can be shown that taxing measures with administratively simple adjustment rules lead to the efficient solution.⁷⁷ Thus, even if private bargaining faces prohibitive transactions costs government action may not.⁷⁸

Moreover, because all parties pay, the Buchanan-Stubblebine argument is inappropriate. At the efficient solution there will be no tendency for parties to move away. Buchanan and Stubblebine assumed a unilateral Pigovian tax. With such a tax the pollution receiver still has a marginal incentive to bargain even at the optimal position. If bargaining costs are underestimated by government, a unilateral tax creates inefficiency. However, the tax mechanism suggested by the Coase Theorem does not generate this problem. When both parties pay a tax, there is no marginal incentive toward further bargaining at the optimal solution even if bargaining is possible.

Other Government Action

Government, however, may find that certain measures can be undertaken to facilitate private internalization.

⁷⁷Maloney et. al. (77) given an example for a Type II externality.

⁷⁸Private bargaining may be prohibited because the property right is uncertain, antitrust laws jeopardize the agreement, extortion may be accused, or consumers are involved. Of course the benefit to the affected parties may be so small as to make internalization inefficient by either government or private action. Government faces none of the former problems, however.

On the other hand, some government action is clearly inappropriate. Examples of these are discussed below.

An implication of the Coase Theorem is that the property rights to a location must be independent of any production. Obviously, the owner of the property right must be able to allow the production mix at the location to change whenever relative profitabilities change. In terms of policy this means that where the usage of government owned properties are involved, leasing agreements should not be associated with specific production requirements. An example of this is the wetlands owned by the State of South Carolina. Current policy provides for the leasing of such for oystering. However, the lease agreement specifically calls for a certain amount of oystering and renewal of the beds. To maintain the ownership right to the wetlands, the leasee must produce oysters even though this may not be the appropriate output at any given point in time. To lock a leasee into a specific output combination (in this case by requirements on production technology employed) will have a detrimental effect on the efficiency of production. Acceptable policy would be to lease the rights to this land to the highest bidder to do with as he wishes.⁷⁹ Where the taxing authority owns the locations it can itself act as the landlord to achieve the optimum solution by maximizing the rents at each location.

⁷⁹There is the problem of completely changing the characteristics of the land. This may be bad because of the national or state heritage, public good aspects.

Zoning causes a problem similar to production requirements. Where zoning captures the basic externality characteristics of land use it may be beneficial because it reduces transactions costs. For instance, a general residential zoning ordinance may be the first step towards residential development internalizing spillover benefits. However, the cost it imposes is that the land use patterns cannot change dramatically even if that is the optimal solution. And when a dramatic change is in question, the process used to determine the efficacy of the change is not as sensitive as the market mechanism.⁸⁰

The effect of judicial interpretation in cases which fulfill the requirements of the Type III externality is effectively zero in the long run.⁸¹ The courts in these cases can do no more than set property rights which ultimately have no effect except to realign the rents. However, if we introduce non-zero bargaining costs or transactions costs into the model, appropriate public policy might be to define the oldest firm as having the property right.⁸² This is true especially if public policy stresses rapid convergence to the optimal solution. Because the property

⁸⁰The political mechanism as opposed to the price mechanism is used to change the zoning ordinances.

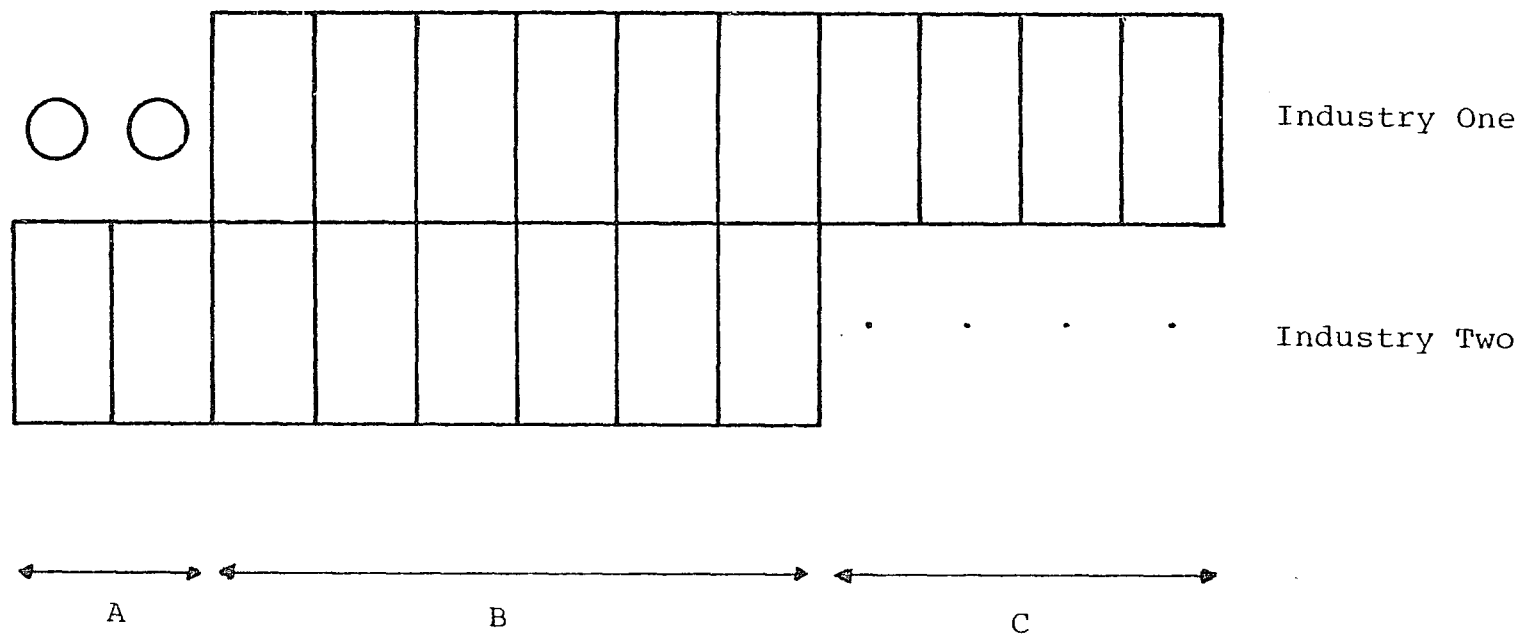
⁸¹For instance, in the cases related by Coase (60) where the courts were used to assign property rights the outcome is expected to have had no effect on industry production.

⁸²Bruce Yandle, Senior Economist, President's Council on Wage and Price Stability, 1976-1977, reports to us that the Environmental Protection Agency is considering such a policy.

right can be defined in either way it also follows that it can be defined in both ways between different pairs of firms involved in the same interindustry externality. The effect of defining the property right with the oldest firm is to prohibit the gaming or extortion that might take place if one industry or the other has the property right at each location.

Consider Figure VI-1. Assume industry one has the property right to pollute. The landlords of the sites appropriate for industry one in Sector A can receive rents in the amount of the excess profits available to the isolated producers of good two located there. In the short run, however, entry or the threat of entry by a polluter might be required in order to gain these rents. In other words, if the landlord at an industry two site is reluctant to give up his rent, the landlord of the industry one site will allow a firm to enter. If entry into industry one does occur, the landlord of the circled site in Figure VI-1 gains rent equal to the profit of a joint venture or equal to the profit of isolated production of good one. This will drive the price of good one down just enough to make it profitable for another firm in industry one to cease production. But the landlord of exiting firm will continue to receive the rent paid by the firm in industry two. This is inefficient if entry and exit are costly or if capital is not perfectly mobile.

FIGURE VI-1



This problem could be eliminated if the oldest firm automatically had the property right. Again it makes no difference on efficiency grounds who has it. The property right definition only determines which landlord gets the rents if the two sites at each location are owned separately. However, if the oldest firm has the property right the landlords of industry two in Sector A, Figure VI-1, would be entitled to the rents regardless of who gets them in Sector B. There would be no gaming involved in obtaining potential rents. For instance, if demand for industry one increased it would cause profit to increase and the number of firms in industry one to increase. The situation in terms of who is paid the rents would be exactly the same as if industry two, as an industry, had the property right: entrants into industry one would be forced to pay the industry two landlords; and the gaming problem described above would be avoided.

Multiple Industries

A final extension of the Coase Theorem is that it applies to multiple industry externality situations. Where any two firms are associated by an externality there is definitely no necessity for government intervention except in terms of the definition of property rights due to equity considerations. This is true even if the two firms are in industries not usually associated by an externality. Consider an example. Assume one industry is an obnoxious polluter causing harm to surrounding (but only

closely proximating) firms wherever its firms locate. Public policy is to do nothing to internalize this cost. If the firm of the random industry that is harmed in each case can profitably move, it will. If not, the appropriate bargaining solution will result. The polluting firms will similarly locate, as they should, where they find it most profitable. Liability for pollution can be assigned to the polluter or not without affecting the output levels of any good.

A Final Word

The one extension of these results that was carefully avoided was to consumers. Whenever criticisms of the Coase Theorem are raised, this is usually found. The normal unwillingness to discuss consumers is the problem of income effects. However, that is not the case here and probably should not be the case elsewhere.

The proof of the Coase Theorem offered here does not sidestep the existence of income effects due to the pollution property rights. It merely shows they do not affect the necessary conditions for a welfare maximum. The rents paid to the location owners are income. This income may change the pattern of demand and affect industry output and aggregate pollution. Even so, the welfare conditions are unaltered.

The implication, then, is if consumers instead of firms are involved, there is no difference. Transactions costs may be increased but assume these are infinite and we are

concerned with the appropriate government policy. The Coasian tax appears appropriate. This may be so but it deserves further study.

In general the form and mechanism of the Coasian tax in large number, privately received externalities requires further investigation. The question of what to do with the tax revenues may not be easily resolved. Because all parties should pay, when consumers are involved they are taxing themselves and paying the revenues back to themselves. This problem may or may not mitigate the application of such a tax.

Regardless of these extensions, the Coase Theorem stands as an important theoretical pillar of externality theory. Examining it in the way suggested by this work points out its richness.

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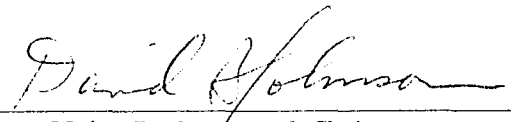
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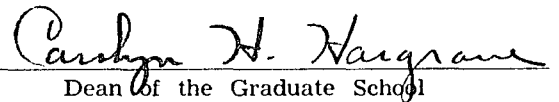
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Title of Thesis: Bargaining Solutions to Externalities

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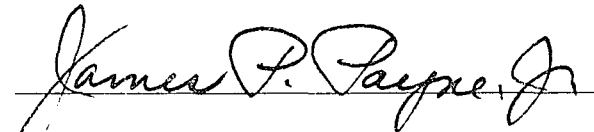


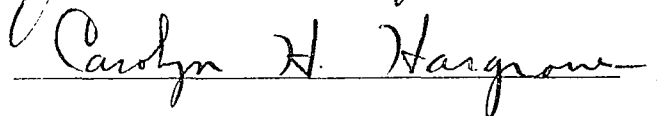
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